SOIL CONSERVATION

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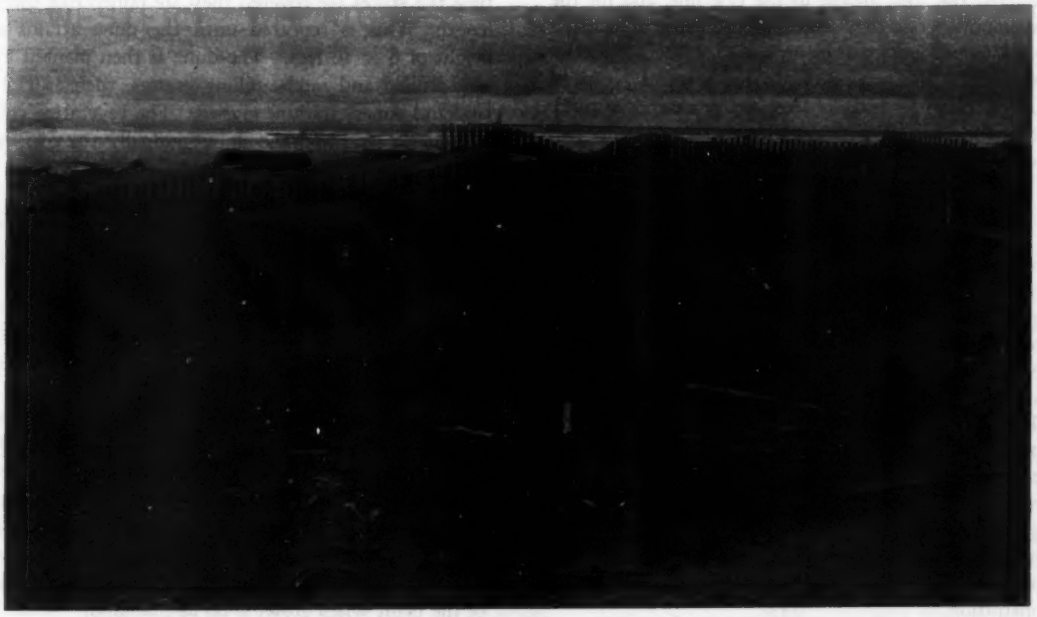

ANCHORING THE CLATSOP DUNES WITH VEGETATION

By E. M. Rowalt

Even after sand from eroded inland ranges and cropland areas of the Northwest is swept out to sea by the swift currents of the Columbia River, the Soil Conservation Service is not done with it. The sand rises—and the phrase is used here in its literal sense—to plague the Service again.

The sand rises in dunes. Much of the sand load of the Columbia, moved about by ocean currents and tides, eventually is swept on to beaches south of the mouth of the river. There the sand is picked up by the winds, which blow prevailingly in an inland direction, and is moved back east, overland. To stop the destructive advance of these sands, and to demonstrate measures of protection for other areas of the Pacific coast similarly affected, the Service established a project at Warrenton, Oreg., a year ago. The project personnel was given the job of lashing down the mobile dunes by vegetative means.

Back from the coast line, in the direction of advance of the surging dunes, lie valuable farm lands, a State road, a Government military reservation, and popular recreational centers. Were the dunes to move on un-

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checked, valuable private and public properties would become enveloped in sand within comparatively few years. Last winter the dunes moved eastward 150 yards along a 16-mile front.

The blame for this condition of accelerated erosion must, as usual, be shouldered by blundering man; but—and here the picture is a bit unusual—the original sin cannot be pushed off upon blame-burdened pioneer generations. It was not their misuse of the land that caused the trouble. To the contrary, the settlers of two generations ago were aware of the unstable nature of the sand below the thin mantle of the soil which covered the area, almost to the tide line, and for the community good they passed an ordinance immediately Clatsop County was incorporated, in the late 1860's, prohibiting the grazing of all land west of Neacoxie Creek, a narrow body of fresh water extending parallel to the coast. For almost 40 years the ordinance was respected; a few offenders, at first, were heavily fined.

Effect of Close-Grazing

But new people came into the region. The newcomers ignored the ordinance, subdivided the land, brought cattle, and grazed the rich grasses. Close-grazing soon killed out the grass, exposing the sands to the unbroken sweep of the winds. The sands piled into dunes which rolled eastward before the almost-constant pressure of prevailing easterly winds. The Neacoxie, half filled with sand, is now a series of ponds traversed by dunes. The dunes have encroached upon the parade grounds of the military reservation, and in parts of the area the county has given up its efforts to maintain open roads to the beach. Clatsop County people are worried, and they observe with growing interest the progress of the demonstration.

Paradoxically, the first step in stopping the advance of the dunes, according to the technique worked out by the Service, is to build a dune. This man-created "fore" dune is built parallel to the coast about 150 feet back from the tide line. Its purpose is to break the sweep of the ocean winds as they lash inland.

Building a "Fore" Dune

To build the dune, a double-line picket fence is driven into the sand in the position desired for the dune. The incoming sands pile over the fence. Each time the stakes are covered they are pulled half their length. This is repeated until the dune attains a height of 8 or 10 feet. The dune is then planted to sand-stilling and sand-catching grasses, such as Holland and American dune grasses. The vegetation collects more sand and the dune gradually rises to its ultimate height of 20 or 30 feet.

A second control step, which is carried on concurrently with the dune building, is the planting of dune grass species at 18-inch intervals over the blowing areas to the landward side of the "fore" dune. Later, as a third step, sod-forming and soil-building vegetation is established; and finally in those areas that will support such vegetation, trees and shrubs are planted for further protection.

The men on the project find that dune grasses are very exacting grasses. For example, T. A. Steele, project agronomist, finds that Holland grass survives only on barren, moving sand. When organic matter accumulates, or when the sands cease to move, Holland grass dies out. Even on comparatively still sand the plant loses the bright green coloring characteristic of the plant when growing on mobile sand.

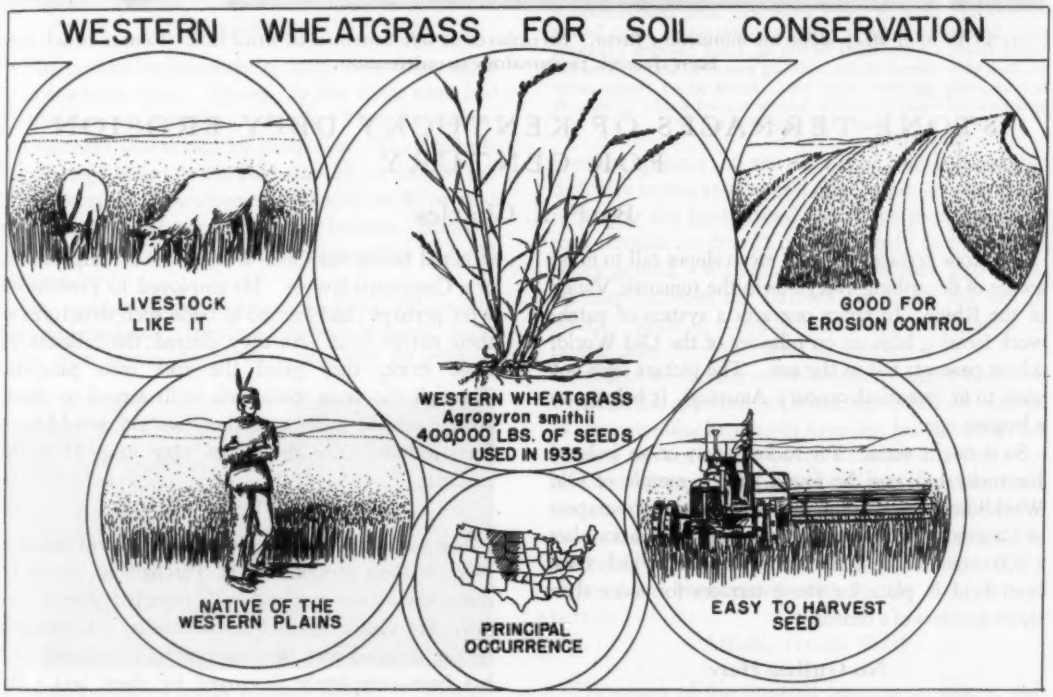
Planting dune grasses

Last fall C. C. C. boys planted an area 100 feet wide and 8,000 feet long adjacent to the high tide mark. Two weeks afterward a storm whipped up enough sand to cover the new planting 20 inches. Before the winter ended storms piled on 10 inches more. Yet when Steele made his counts in June he found that 95 percent of the Holland grass plants survived.

Various Plants Tried

Steele and M. V. Penwell, camp superintendent, are not prepared to say what the plant succession will be eventually. They are investigating various species of native and imported grasses, and will select the most promising of these to succeed the dune grasses.

What will become of the area once it is stabilized? Ultimately, portions of the area back from the water front may be returned to pasture use. But the area lying west of the Neacoxie Creek, where stabilization measures are concentrated, can never safely be used for grazing. Perhaps eventually it may become a center for grass-seed production. Clatsop County is a leading producer of bentgrass seed.



THE WEATHER HASN'T CHANGED

Rainfall on the Great Plains averages about 20 inches. Sometimes it falls gently, but more often it comes in brief torrents that rush off the land, carrying away vast quantities of precious soil and increasing the likelihood of floods. Cycles of dry years appear, as well as cycles of what might be called wet years. By and large, rainfall is the same that it has always been and wind velocity, also, has retained the pace of the centuries.

The significant difference now is that more land is exposed to damage by wind, sun, and rain than formerly. Low rainfall for 5 years, overgrazing for a number of seasons, and the tremendous expansion of the wheat acreage, are the principal factors which made it possible for wind and sun to do so much damage within recent years. The rapid increase in size of the affected areas, and the gradual exhaustion of the grass roots and soil-binding humus under conditions of cultivation are important factors that justify deep concern.

MOISTURE FOR THE FALLOW PERIOD

In many areas of the Great Plains the original vegetation has been almost totally destroyed by overgrazing and has been replaced with less palatable plants. On great stretches of range land less than 50 percent of ground cover exists today, and the late drought is responsible for still further damage. Large acreages of crop land, where the fallow system is used, have suffered from wind and water erosion. Due to rapid run-off of rain water, a relatively small percent of moisture is available for the building up of reserve for the fallow period. Thus the moisture content at seeding time is so low that seed may not even germinate.

Present known soil and water conservation methods, if properly applied, are adequate to hold the soil and insure crop production on the better lands of the Great Plains. It must be understood, however, that considerable land, widely distributed, is not suited to crop production and should be returned to the grass cover as soon as possible.

General view of steep slope on monastery farm. Structures at left continue around hill. Center bench has been cleared, preparatory to cultivation.

STONE TERRACES OF KENTUCKY DEFY EROSION FOR CENTURY

By F. E. Charles

Old stone terraces on high, steep slopes call to mind scenes of flourishing vineyards in the romantic Valley of the Rhine. In fancy one sees a system of patchwork farming high up on hillsides of the Old World, where peasants toil in the sun. The picture does not seem to fit twentieth-century America. It belongs to a bygone age.

So it might seem. Yet tucked away on an isolated Kentucky hill may be found such a sample of Old World farming. Within easy view of the skyscrapers of Cincinnati, yet seemingly far from civilization, lies a 100-acre hill farm, the steep slopes of which have been held in place by stone terraces for more than three-quarters of a century.

No Gullies Here

The farm is owned by the Benedictine Order of Monks and once was the site of a monastery. Today the farm is operated by a farmer who tills the place as other Kentucky farms are tilled although the monastery land offers striking contrast with other hill farms of the Ohio valley. Although the insidious fingers of erosion have gullied the slopes of other farms in the neighborhood, the terraced hillsides on the monastery farm remain unscarred.

Accompanying photographs suggest the nature of stone terraces on the monastery farm which perches on a ridge just west of Covington, Ky. The saga of the place says that some of the terraces were constructed before the Civil War, under the supervision of a Cincinnati lawyer. He employed 10 Frenchmen who, perhaps , had learned to build such structures in their native land. As they cleared the hillsides of loose stone, they piled the rock into parapets. Through the years these rock walls served to check erosion which, under normal cultivation, would have been serious, since the slopes vary from 35 to 50 percent.

Nearly Perfect Control

The terraces have been nearly 100 percent efficient in controlling erosion, A. H. Paschall, in charge of conservation surveys, region 3, reported after a survey. No visible signs of active erosion are apparent on the terraced area, whereas nearby unterraced land has been completely destroyed by sheet and gully erosion.

Terraces on the monastery farm reduce the steepness of slope to a point where tillage operations are comparatively easy. The reduction has a marked effect in retarding the rate of water run-off.

Holds Water

Depth of soil between terraces averages 5 feet, varying from 2 feet at the base of the uphill terrace to 8 or 10 feet at the downhill terrace. This thick mantle of soil provides an excellent reservoir for storage water. It contrasts strikingly with the badly eroded soil on nearby cultivated lands where

frequent gullies slash the slopes from top to bottom. Most of these gullies reach down to bed rock. The soil produces little or nothing. Sheet erosion between gullies has removed the soil to a depth of 24 to 30 inches.

An acre of the terraced land has about 10,000 tons of total soil mass; an acre of the unterraced land about 5,000 tons. The difference of 5,000 tons represents loss due to erosion, most of which is topsoil. From the standpoint of long-range economy, the original cost of building terraces on the monastery farm would, therefore, seem to be justified.

Construction

The method by which the terraces were constructed is not wholly clear. Apparently the walls were laid in trenches, excavated to bed rock. Then the soil between them was sloped by manpower. On a hillside paralleling United States Highway 25 are located the oldest terraces. The slope here varies from 50 percent at the top to 35 percent at the bottom. Between terrace walls the slope has been reduced to 13 to 30 percent.

On another slope, not visible from the much-traveled highway, benches between terraced walls have been leveled to between zero and 20 percent.

Alfalfa grown on bench without liming or fertilizing, the terraces having not only retained the soil but preserved the plant food.

These newer terraces are said to have been constructed during the Civil War, after the Order of Benedictine Monks obtained possession of the land. The monastery once employed 20 workmen in its vineyards and, not many years since, there were 35 acres of grapes on the place. The monastery was closed in 1919.

Well Preserved

The stone terraces are in a good state of repair, with the exception of an occasional flaw caused by hunters tearing them apart in search of rabbits. The present operator of the farm has had considerable difficulty in this respect and only a year ago succeeded in having the land posted as a game preserve. The rock terraces are from 3 or 4 feet to 10 feet in height above ground. Wall thickness varies from 2 to 6 feet. Benches between the terraces are 75 to 100 feet in width. Steps at convenient locations lead visitor or husbandman from one level to another.

Effectiveness of the stone terraces in preventing erosion emphasized in this view of a rain-drenched, sun-bleached area not more than 50 yards from terraced area, on opposite slope. Once a vineyard. So severely eroded that 24 to 30 inches of topsoil have been removed between gullies, while bottoms of gullies now reach to bedrock. At left may be glimpsed a fringe of black locust grove which is rapidly helping to retrieve the area.

Modern soil conservation engineers might well contemplate the effectiveness of the riprap terrace outlets. Water catapults harmlessly from one bench to another because the outlets are paved with stone. There are no signs of erosion where water has run over these outlets, although it is obvious that vegetative cover keeps the amount of run-off water at a minimum. There is evidence that the natural waterways on the slopes have been paved with rubble from top to bottom.

Alfalfa Grew Well

The oldest of the terraced benches are not in cultivation today and are grown to weeds and forest. On the newer terraces part of the old vineyards have been cleared out to permit field cultivation. Last year one of the benches was planted to alfalfa and, although the weather was most unfavorable, a good stand was obtained. Another bench has been cleared, ready for cultivation.

Agronomists and foresters find points of interest on this monastery farm. Grass, trees, and shrubs, including honeysuckle, have come into the benches since they were abandoned nearly two decades ago. Black locusts are creeping in rapidly and there is a

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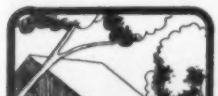
SHE LIVES BY THE SIDE OF AN OLD-TIME MILL



By Charles B. Maits, Jr.

There is a little gray-haired old lady living in Lancaster County, Pa., who can tell you something about soil erosion, and what it can do during the course of a lifetime. Her home is on the west branch of the Octoraro Creek near King's Bridge. Nearby stands King's Mill—an old-time grist mill, built more than a century ago, and in practically continuous operation, serving Lancaster County farmers till just a few years ago. The old log-and-masonry dam which spans the little creek, and which used to check the rushing waters in the rainy seasons, is a familiar landmark to all the residents in the neighborhood. They call the old structure King's Dam.

The Dam Went Out

During the summer of 1934, heavy rains washed out old King's Dam and incidentally gave an interesting, if somewhat costly, object lesson in soil erosion.

On viewing the damage, engineers of the Lancaster County project of the Soil Conservation Service discovered that the water pouring through the break in the dam, had gouged a deep V-shaped channel into a deposit of silt 11 feet deep—piled up to the very brink of the old spillway. Examination of this cut disclosed the fact that the richest soil lay at the bottom, while that towards the top was poorer and more sandy. Such a condition is a sad reminder of the fact that even the rains in Lancaster County can no longer find quite so rich a soil to wash as was formerly the case.

Calculations by the Soil Conservation Service showed that this one small dam had backed up approximately 27,000 tons of rich top soil, not to mention the considerable quantity of silt which undoubtedly had been washed over the top of the dam, and carried through the mill-race to flow over the old wooden mill-wheel. From the cut alone, some 7,250 tons of soil were flushed out when the dam gave way. The total watershed area contributing to this accumulation is about 1,200 acres, of which approximately 75 percent is cultivated farm land.

But this is only part of the story. The gray-haired old lady who lives nearby says that, many times before, the waters of the Octoraro have broken down old King's Dam. Each time the unloosed flood has torn the embarked silt from the break of the dam, to deposit it somewhere else further down the stream.

Continuous Silting

According to the little old lady, it generally requires from 1 to 2 years after the dam has been repaired, before the hard-working Octoraro can again accumulate enough silt to fill up the channel caused by the break. Thus, the deposits washed from the cut indicate a loss of about 5 tons of soil per cultivated acre per year, from the farms located above the dam.

From this it is easily calculated that during the lifetime of this little lady—she is over 80 now—approximately 400 tons per acre, or about one-half of the total topsoil, has been lost from the cultivated land within the boundaries of this one small watershed.

The old millwheel, if it could speak, might tell many an interesting tale of the "good old days." And the little old lady, when she was a little girl, knew these same "good old days." Both of them watched and listened, year after year, as thrifty, hard-working farmers drove their Conestoga wagons, piled high with golden grain, to the old mill. Both of them heard those farmers discuss the problems of their times while they waited for their grain to be ground between the ponderous old millstones. And perhaps the old millwheel (if it could think) may have felt a little sad as it turned on and on, grinding the grain, because it was driven by the water that was robbing those farmers of the very soil in which that grain had flourished.

Other Streams as Destructive

Much water has flowed over many dams, in all sections of the United States, since the day King's Mill was built, and there are many streams that have carried heavier burdens of silt than the Octoraro—chuckling and boasting as they rushed over other old millwheels

(*Continued on p. 71*)

A GRAPHIC METHOD OF SHOWING THE RELATIONSHIPS OF EROSION, SLOPE, AND COVER

By H. Howe Morse [1]

Pastured woods showed a greater amount of erosion than pasture in a recent study of planimeter data of the Salt Creek project, Zanesville, Ohio. Such a conclusion appeared to be exactly contradictory to general field observations. Further examination, however, showed that most of the woods occurred on steeper land than the pastures and that the woods were more effective than pastures in controlling erosion if the erosion was compared on similar slopes. Therefore, it became necessary to take into consideration the slope of the land when comparing the cover and erosion.

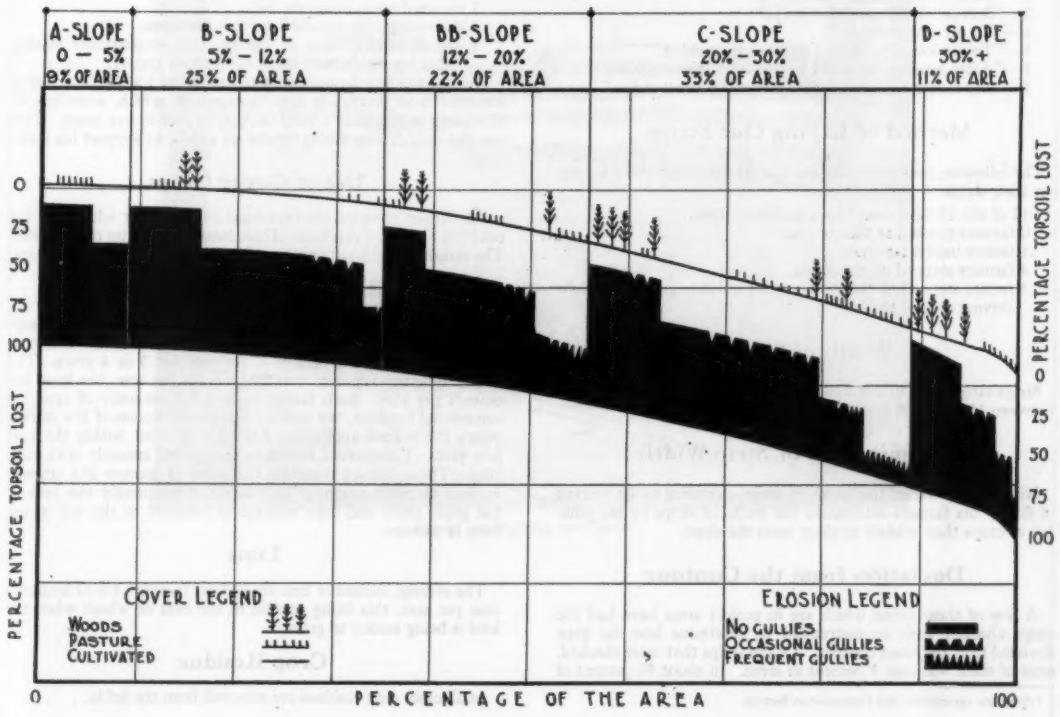
The presentation of three or four factors in a table or graph, however, is fraught with the danger that the relationships may be obscured by voluminous tables or, if in a graph, by a large amount of detail. Nature itself suggested a simple method of presenting these relationships graphically. An illustration of the method is given in the accompanying graph.

The original surface of the ground was graphed showing the actual slope of the land, using the percentage of the area as the abscissa. Below this line another was drawn showing the amount of sheet erosion which has taken place on each slope class, proper symbols being used to indicate the instances where gullying was combined with sheet erosion. Then the cover was indicated on the original surface to depict the relationship of cover and slope to the erosion which has occurred. The finished graph shows the percentage of the land in each slope class and the amount of erosion on the different slopes. It also gives the distribution of the cover on the different slopes and their relation to the erosion on those slopes.

[1] Soil scientist, region 3, Soil Conservation Service.

PLATE Nº 1

METHOD OF SHOWING - COVER, SLOPE AND EROSION



LONG EXPERIENCE WITH STRIP CROPPING CITED BY FARMERS

By Guy C. Fuller [1]

During the past summer I personally visited a number of farmers in southwestern Pennsylvania and southeastern Ohio who have for many years made strip cropping an integral part of their operations.

For convenience in assembling the information I desired, I carried with me a questionaire covering such points as when strip cropping was begun, reasons for adopting the practice, and the results obtained.

Fifteen farmers were contacted. Of these, 14 are owners and operators and 1 a tenant.

The average farm covers 112.8 acres, the largest 193, and the smallest 39. The average number of acres of crop land is 45.8, pasture land 33.3, and woodland 20. The 45.8 acres of crop land were at the time of the survey about equally divided between corn, oats, wheat, and grass—that being the common rotation. These 15 farmers have been practicing strip cropping for a long period of years—10 years being the shortest period and 28 years the longest.

Examination of the data reveals the following reasons for starting strip cropping:

4—"To save the soil."
4—"To prevent erosion."
1—"To keep the soil at home."
2—"Because dad farmed that way."
1—"To prevent gullying."
1—"To get longer fields and to prevent washing."
1—"After ruining one field I had to start strip cropping."
1—"My father and grandfather farmed by using strips."

Method of Laying Out Strips

The following summary indicates how farmers went about laying out their strips:

12 of the 15 have their strips on the contour.
9 farmers guessed at the contour.
1 farmer used a tapeline.
4 farmers stepped off the strips.
1 farmer stepped off the strips and set stakes to guide him while driving around the hill.

Width of Strips

Strips range from 50 feet to 450 feet in width, the average falling between 150 and 200 feet.

Determination of Strip Width

Nine farmers varied the width of strips according to the percent of slope. Six farmers determined the width of strips by the number of crops they wished to place upon the slope.

Deviation from the Contour

A few of these farms which are in project areas have had the strips checked with an instrument to determine how far they deviated from the exact contour. Of the strips that were checked, none of them was over 3 percent in error. In about 50 percent of the cases slight changes were made in the strips after the first year of cropping. The changes were made in the countor lines where there was evidence of erosion during the first year of strip cropping.

Crop Rotation

With two exceptions, corn, oats, wheat, and grass constituted the crop rotation. Two individuals omitted wheat because they felt it was removing too much from the soil. This may or may not have shortened their rotation, for they plowed the meadow strip giving the lowest yield and providing the least protection against erosion.

Cropping Plan

The same cropping plan is used by all 15 farmers; that is, they never plow two strips side by side on the slope. Occasionally due to failure in obtaining a grass stand, this cannot be avoided. In that event, a close-growing crop such as oats or wheat is placed on the slope and reseeded with the grass mixture. These farmers favor a meadow or grass strip below a plowed strip.

Crop Yields

As to crop production—
7 farmers reported better yields.
2 believed that on an average they were gaining a little each year.
3 reported maintaining yields.
1 enthusiastically reported one-third increase.
1 was thoroughly sold on the practice, emphatically stating that his yields were six to eight times greater.

The outstanding farmer contacted reported his yields as being increased from parctically zero to excellent, which, according to his figures would mean a yield increase of four to five times. This was the only farmer giving figures on yields, to support his statement.

Use of Cover Crops

One farmer reported the occasional use of rye or wheat. It has not been a common practice. Three intend to take up this practice. The remaining 11 have never used winter or summer cover crops.

Fertilizer—Kinds and Amounts

The average amount of fertilizer, mainly superphosphate, supplied on all farms, is 190 pounds per acre. In a few instances complete fertilizer has been used for the past 3 or 4 years. The largest quantity reported was 250 pounds per acre, the least 100 pounds per acre. Each farmer realizes the necessity of applying commercial fertilizer, but in many instances, because of low market prices the normal application has been reduced within the past few years. Commercial fertilizers are applied annually with each crop. These farmers recognize the value of manure and attempt to feed as much roughage as possible, consequently the bulk of the grain straw and corn ensilage is returned to the soil in the form of manure.

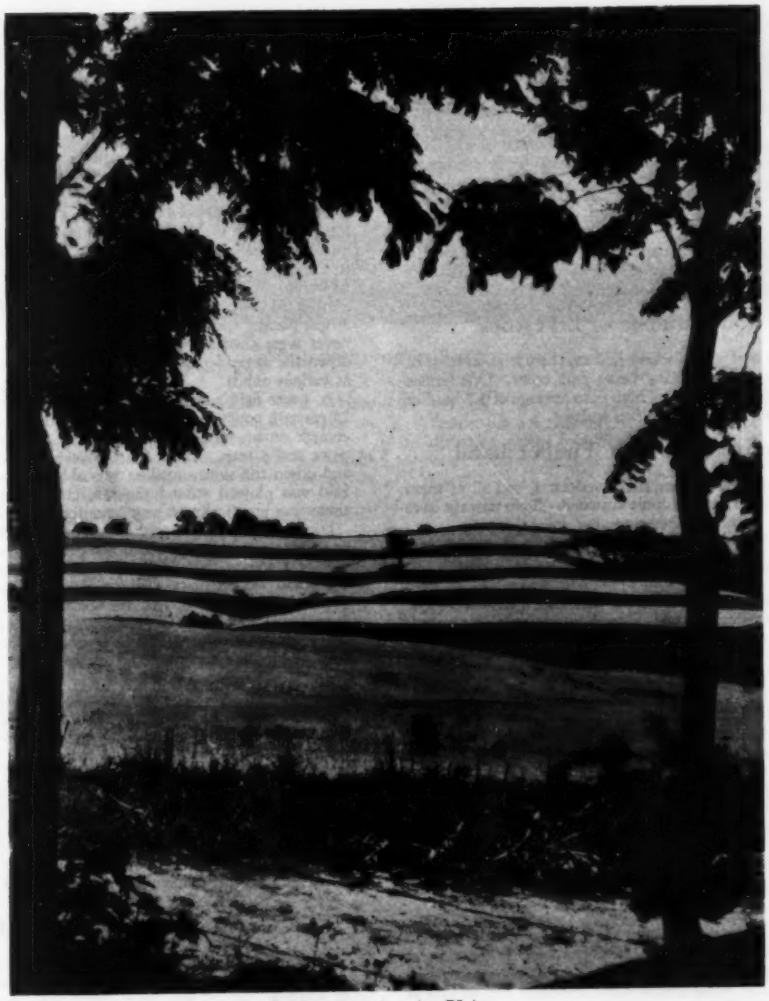
Lime

The average amount of lime applied per farm is 1 ton of hydrated lime per acre, this being applied in the oats or wheat when the land is being seeded to grass.

Crop Residue

In all cases crop residues are removed from the fields.

[1] Associate agronomist, Soil Conservation Service.



Strip cropping in Ohio.

Terraces

In no case has terracing been done, and each farmer reported that terraces would not be beneficial in his strip-cropping program.

Pasture Management

Eight of the fifteen farmers are practicing alternate grazing, the other seven continuous grazing.

Pasture Treatment

One of the fifteen farmers reported pasture treatment, and that was in the form of manure only.

Supplemental Pastures

One farmer has been growing soybeans for several years. Another has been growing soybeans and Sudan grass for supplemental feed, 1 to 3 acres per year.

Number of Silos

Ten of the fifteen farmers have silos and use corn as silage. In two instances, the farmers husked part of their corn and used this as concentrate in ground form for dairy cows.

Kind and Number of Livestock

Including cows, beef animals, and heifers, there is an average of 22.2 head per farm, the majority being milk cows. One farmer has 75 sheep, another 25 sheep. There is an average of 3.7 head of horses per farm, and four farmers own tractors.

Treatment and Use of Timber Land

Six of the fifteen farmers graze their woodland, and all of them cut their own posts and obtain some firewood. Two farmers have applied grass seed to their timber land after some thinning.

Protection of Natural Waterways

In all cases a good permanent sod is maintained in waterways. This point was stressed by each farmer, and it was emphasized that the sod strip should be kept "plenty wide."

Soil Type

As they are within the watershed area, five of the farms visited have been mapped by members of the Soil Conservation Service. The dominant soil on these five farms is Gilpin gravelly silt loam. Major soil types on other farms visited are Westmoreland silty clay loam and Belmont silty clay loam. The average percent of slope is BB, the majority falling between 15 and 25 percent. There are some 30-percent slopes and a few 5-percent, with an average of 3 erosion, the majority of this falling below 50 percent on the five mapped farms.

Types of Erosion

Sheet and gully erosion have been most serious. Sheet erosion was most serious where the strips were too wide at the time of initiating strip cropping, but this has been corrected by narrowing the strips. On many farms gullies were prevalent and serious at one time, but through proper treatment and use of vegetation every one has been filled or stabilized.

Strips and Conservation

Two farmers reported strip cropping as being "inconvenient." Eleven reported that it was "more convenient." One said it was the "only way to farm." One reported that he could plow 50 percent more per day. Every farmer agreed that it was more economical.

Advantages

All farmers reported that it was to their advantage to practice strip cropping. Experience had taught them that it was the only possible way to farm the hills, and after their fields were stripped and they had become adjusted to the practice, nothing would turn them away from strip cropping.

Disadvantages

Two farmers reported grazing difficulties; three stated that it was inconvenient to cross the strips in passing from one strip to another, and one farmer reported a great disadvantage when the strips were very short.

The following comments are of considerable interest and are presented here in the way in which they were given to me direct from the owner:

F. M. Giffin, a noncooperator, purchased a 54-acre farm in southeastern Ohio in 1907 and shortly after increased his acreage to 90. In 1908 he observed that grass prevented erosion and caught the silt carried from plowed fields above. He started strip cropping. His strips range from 4 to 8 rods in width, and are placed approximately on the contour, the width of the strips varying according to the slope. He guessed at the contour lines when dividing the fields into strips.

After the first crop year, he made very slight corrections in the strips, placing them more nearly on the exact contour. The lines never were checked with an instrument, but were varied up or down the slope depending upon the amount of erosion occurring at various points.

A 4-acre field adjoining his barn lot, with an average slope of 25 percent, contained 4 deep gullies. For 3 years he did not grow enough on his farm to feed his livestock, which consisted of 12 cows and a team. He and his boys plowed these gullies in, up and down the slope, until he was able to cross them. Then the field was plowed around the hill, crossing the gullies. In 1908 there was practically no vegetation of any kind on the field.

Four bushels of grass seed was applied to this 4 acres, with rye as a nurse crop; but Giffin did not get enough grass to cover completely 1 square rod. The field was plowed again in the fall of 1909, and seeded to rye, which was harvested in the spring of 1910. Two and a quarter bushels of grass was seeded in the second rye crop, and a fair stand was obtained after adding a half ton of hydrated lime, 250 pounds of superphosphate, and a small amount of manure per acre.

In 1912 the field was plowed, and put in corn, then oats, and seeded back to grass, which consisted of alsike, red clover, and timothy. The field was not plowed as long as this sod provided a good cover and yielded some forage—this covering a 3- or 4-year period. The field was thereafter included in his regular rotation of corn, oats, and grass.

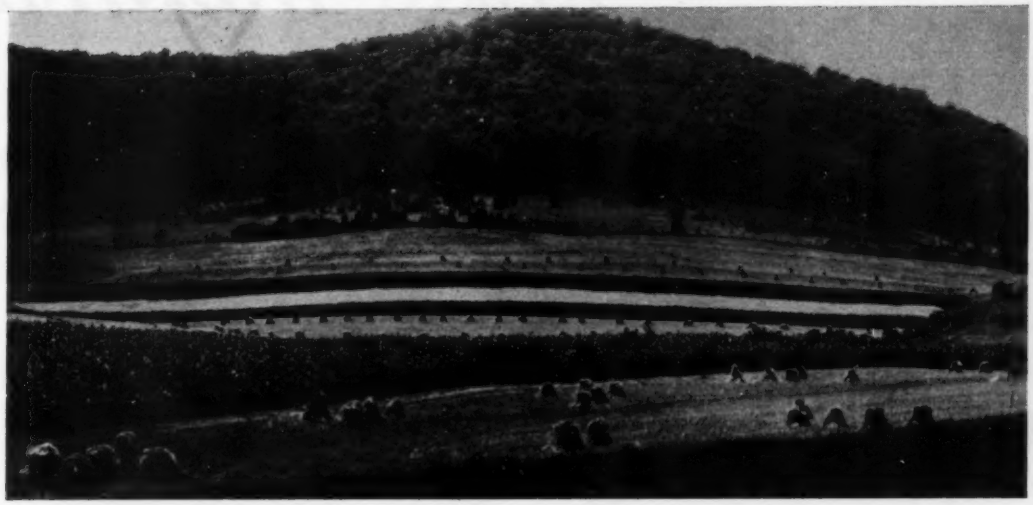
In 1918 Mr. Giffin started using alfalfa and has since been using it in the following mixture: 15 pounds of alfalfa, 12 pounds of timothy, and 8 pounds of red clover. The second cutting of alfalfa on this field at the present time ranges from 18 to 24 inches in height and is an excellent stand. When again this field is plowed Mr. Giffin expects to divide it into two strips.

Grass Mixture Controls Erosion

The crop rotation followed by Mr. Giffin consists of corn, oats, and the grass and legume mixture. He follows no definite order of rotation, but plows the meadow strip producing the lowest yield for corn. Mr. Giffin states that alfalfa alone does not prevent erosion, but by using the grass mixture greater yields are obtained, and erosion is held to a minimum.

When Mr. Giffin first grew oats on his strips, yields of 15 to 20 bushels per acre were obtained; in 1935 he harvested 64 bushels per acre from the same strips. In 1932 he failed to obtain a stand of grass on one strip, and it was put into wheat and reseeded. A yield of 42 bushels per acre of wheat was harvested.

At the present time, 37 purebred Jersey cows in addition to 1 imported purebred bull, 4 horses, a tractor, 2 trucks and a new



Strip cropping in Wisconsin.

family automobile may be found on Mr. Giffin's farm, which, undoubtedly, is an indication of what he has been able to do on those steep slopes and a comparatively small acreage

Some 30 of this farmer's neighbors have taken up the practice of strip cropping during the past 10 years, because they observed the higher yields obtained on his farm.

The Ohio State University called upon Mr. Giffin to give a talk for the benefit of other farmers in the State. He had pictures of his farm, showing the strips, and he gave an accurate narrative discussion of his practices.

J. C. Boyle, 7 miles southeast of Washington, Pa., remarked that during a 4-year period one of his neighbors abandoned one field because of erosion.

An Example in Point

J. D. Martz, in the vicinity of Vandergrift, Pa., relates the following story about a 30-acre field across the fence from where he is practicing strip cropping, the slope and soil type being approximately the same.

In 1898, Mr. Martz helped his neighbor thresh oats from this field, with an approximate yield of 37 bushels per acre. In 1924 they put up 25 tons of hay. After that the farm changed hands, and the purchaser plowed the entire 30 acres as one field. "Today", Mr. Martz remarked, "it would be impossible to ride a horse over that field." Gullies have been deepened from 2 to 3 feet during the past year. Across the fence, in Mr. Martz's own field, satisfactory crops are obtained and there are no gullies.

Narrowed His Strips

Fred Weiss, a cooperator in the vicinity of Indiana, Pa., made this statement: "I would have had a very good farm if my strips had been much narrower at the time they were laid out. Although I have no bad gullies, considerable sheet erosion occurred because the strips were too wide at the outset. I have, therefore, narrowed them down considerably."

H. H. Wetzel is so thoroughly sold on strip cropping that he would carry on this practice if his land were level.

Father Established Practice

Taylor Pepper, 1 mile north of Centervilæ, Pa., has never farmed without using strips, because it was the way his father and grandfather farmed, and when he bought his present place he stripped his fields the same as they had stripped theirs. Mr. Pepper has not only used strip cropping but has made a practice of diverting water from the low places on to the higher areas by using ditches, small dams, etc. He never allows a gully to get started.

Conclusion

Although accurate measurement was not made on all farms, it is believed that the average slope of all cultivated fields would fall between 15 and 25 percent. Every farmer visited has been able to control gullies by the use of vegetation and diversion of water. Although erosion has occurred on most farms, it will fall below 50 percent, as is indicated by the crop history.

Sheet erosion has been responsible for most soil losses because the original strips were too wide. The common grass-mixture used by these farmers consists of alfalfa, timothy, and red clover. Two farmers are of the opinion that alfalfa alone does not prevent erosion, and for this reason, and because it gives them greater yield of forage, they are using the mixture.

AN OLD-TIME MILL

(*Continued from p. 66*)

with their booty of priceless topsoil, stolen from countless thousands of farms throughout the land.

Is it any wonder that serious-thinking farmers, the country over, scratch their heads as they stand on their eroding land and wonder why crops are not quite so good as in their boyhood? To their fathers the soil was something solid and dependable. No depression or disaster could steal it away; no laws of man could alter its trustworthiness. Now their sons wonder, and are not so sure.

They could learn the story from a little gray-haired old lady who has lived beside the Octoraro for a long, long time.

The Inspiring Golden Ga

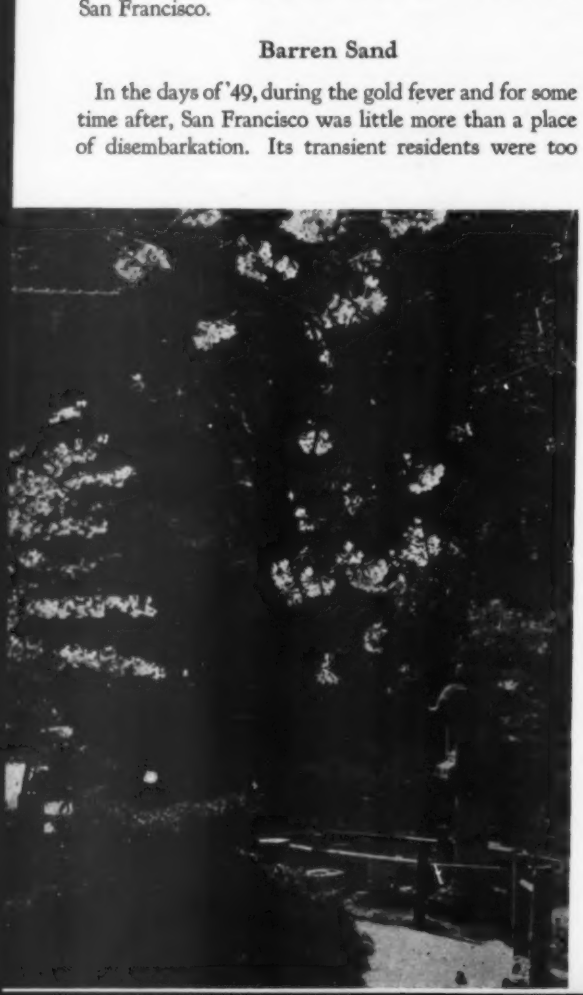
by

ERIC WALTHER Park Botan

Increasing attention is being given to the task of reclaiming waste lands, either for agriculture or in the interest of scenic and aesthetic appeal. An example of such an effort, outstandingly successful by common consent, is the case of Golden Gate Park, San Francisco.

Barren Sand

In the days of '49, during the gold fever and for some time after, San Francisco was little more than a place of disembarkation. Its transient residents were too busy to dream of a glorious destiny for this collection of shacks and tents at water's edge. The entire westerly part of the city and county was a long succes of sand dunes, shifting farther eastward with every breeze from the ocean bea So dreary a spectacle was this desolate area that an official survey spoke of i "uninhabitable by man." In spite of this, a few enterprising individuals squat on the more desirable locations in the western portion of the city, either in per or by proxy in the form of hired, armed guards. By the time that law and or came to the fore, little was left of these former "Pueblo lands." As the outcome long battle by a few public-spirited citizens, a compromise was arranged by wh 1,000 acres were returned to their rightful owner, the city, to become a public pa Many were the scoffers who doubted whether there would ever be anything to sh for the taxpayers' money sunk into this desert of sand dunes. Since then, howev Golden Gate Park has become world famous. Today it ranks among the forem of the country—a monument to the civic spirit of San Francisco's citizens and to invincible faith of its veteran superintendent, John McLaren, now in his fifti year of service.



Making Over the Desert

The transformation of this desert into a garden, the long years of experimentat and experience, yield many useful lessons to the soil conservationist.

The first step essential toward reclaiming this area was to prevent further mo ment of the sand dunes. Some preliminary attempts made use of barley and lu seeds, sown during the rainy season, but success was only partial. Not until famous beach grass, *Ammophila arenaria*, was imported from France at the suggest of one of the Vilmorins, was any real progress made. It is not too much to say t without this grass there would be no Golden Gate Park today. Its principal virt is its ability to survive being covered, seconded by the binding power of its lo tough roots. Usually planted from divisions in the winter or early spring, it is a to live through a 6-months' rainless summer with only such moisture as condens from the local fogs.

Only now was it possible to consider planting anything else, and of the ma plants tested only a few proved able to live in the almost pure quartz sand dev not only of plant food but as dry as any desert for nearly half the year. Outstan ing among the survivors were two Australians, *Leptospermum laegatum* a *Acacia longifolia*. Both thrived under the inhospitable conditions and served as t shelter for more decorative, taller trees. Of the latter the most successful turn

ng Story of Gate Park

Park Botanist.

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out to be two Californians, the Monterey pine and the Monterey cypress, supplemented by *Eucalyptus globulus*, the blue gum from Australia.

Water Problem Solved

With these as a framework on the foundation of pure sand, was painted the finished picture of our park, into the making of which went much labor and material even more prosaic. One of the important factors contributing to the park's success in earlier days was the street sweepings, brought here from all over the city. More recently a sewage-disposal plant has been installed in the park, not only adding to the water supply, but also producing valuable fertilizer. The water problem, always an acute one, was solved by the discovery of an apparently ample supply in the park itself. A large steam pumping plant, supplemented by two windmills near the ocean, yields a daily total of nearly 2,500,000 gallons of water.

(*Continued on p. 82*)

Pictures by the author. At the upper left we see silhouetted against the sky the famous beachgrass, Ammophila arenaria. ***Below it is a view in the Japanese garden, as it is in cherry-blossom time. Above, to the right, is a flowering spray of*** Leptospermum laevigatum; ***and nudging it closely are flowers and foliage of the blue gum,*** Eucalyptus globulus. ***Also shown, is a refreshing glimpse of the tropical jungle of tree ferns.***

UTILIZATION OF SMALL WATER POWERS[1]

By H. H. Bennett[2]

The reawakening of interest in little waters and small water powers is a significant example of the profound transformation of the traditional American attitude toward the conservation and use of natural resources which is visibly in process throughout the Nation today. We are beginning soberly to realize that we have been a prodigal people and that the magnificent natural heritage with which we began our career as a Nation is not inexhaustible. In a new sense, we are becoming land and water conscious, forced by tragic experience of floods, erosion, dust storms, and drought to recognize the threat to the permanence of the economic foundations of our civilization which our traditionally individualistic exploitation of land and water resources has brought upon us. Not isolated technicians alone, but an increasingly substantial number of those who determine effective public opinion, are envisaging conservation in terms of the total resources of whole drainage basins, and of the interdependence of those resources and their users. The revival of interest in the conservation of little waters and the utilization of small water powers is significant principally as evidence in confirmation of the reach and penetration of the visible process of psychological readaptation which as a people we are making as a felt condition of national survival.

The story of our use of little waters and small water powers presents a typical cycle. The colonial history of America is vitally interwoven with the water wheel, with small power installations on great streams and small for the localized service of individual households, individual mills and factories, individual communities. The pioneering and dominant position which for generations New England held in the development of the factory system was due to the rare combination of ingenious settlers mechanically inclined with a glaciated terrain abounding in lakes, ponds, and streams of dependable flow and regulated by rock-bound channels. But New England was only a special case of what happened along both slopes of the entire Appalachian Mountain system. In the minds of the rugged pioneers, facing a boundless undeveloped continent, the streams, like their forest cover and their bordering soils, seemed inexhaustible and permanent as the hills.

Then came coal, the steam engine, the concentration of vast populations in commercial and manufacturing centers, a steady decline in the number of small water-power installations. For millions of Americans the very visual imagery associated with water changed from brooks and rills and wooded hills to pipes and taps and valves. What happened to the headwater ponds and marshes and lakes, the forest cover, the small tributary streams, did not disturb their minds so long as valves and taps flowed. Engineers appear to have shared with the urbanized layman this narrow and short-sighted preoccupation with impounded streams as water supply. According to the Water Planning Committee of the National Resources Board, "notwithstanding the patent desirability of comprehensive stream regulation in most of the North Atlantic drainage areas, the Hudson River Basin and a few minor basins are the only ones having either the plans or the administrative machinery requisite to achieving such regulation." Of the Delaware River, to cite a specific instance, this committee reports that regulation of the main stem is completely lacking with the result that not only power sites of great importance remain undeveloped, but even potential water supplies for New York, Philadelphia, and other metropolitan areas are not utilized. Water famines have threatened metropolitan areas even in years when vast damage has been wrought by floods and for the same reason. Such grim realities are compelling attention, such as that evidenced by the work of the Water Planning Committee, to the need for comprehensive stream regulation and the maximum conservation and use of all the resources upon which socially effective regulation depends.

The cycle to which the steam engine so largely contributed through the concentration of population in manufacturing centers, the steam locomotive helped to induce through the dispersion of the agricultural population over the western prairies and plains. In the minds of the land-hungry homesteaders, the water table into which they sank their wells seemed as eternal as had the hills and surface streams of the East. Established in proud isolation and proceeding each man to himself, they took little account of the relation to the water table of the distant headwater marshes and lakes, of the grassy ground cover, or of the innumerable small streams that regulated the run-off of melting ice and snow. According to the report of the Mississippi Valley Committee, 95 percent of the people in the Mississippi River Basin, outside of the larger cities, depend upon subsurface water for domestic and stock watering purposes. Due in large measure to mistaken agricultural practices and to the absence of any comprehensive public control of the total water resources, the water table, in vast stretches of the upper basin, has fallen at a dangerous rate, in some instances by as much as 30 feet; ponds and springs have dried up; marshes which functioned as indispensible natural reservoirs have been destroyed, sometimes through unwise drainage; the level of important headwater lakes has been seriously lowered. Duststorms and unprecedented drought over wide areas have made the people, both those directly affected and throughout the entire Nation, acutely aware of the relation of total water resources to agriculture, of types of agriculture to water supply, and of the need of dealing with the combined problem of soil and water conservation as a whole through the planned rehabilitation and control of entire river systems. Such plans have only recently been put into initial execution in the basins of the Columbia, the Missouri, and Mississippi, and most comprehensively in the Tennessee Valley. Obviously the cost of such colossal undertakings is enormous. Fortunately those who have been entrusted with their execution are vividly aware of the bearing of their work not only upon the well-being of the people in regional areas but also upon the standard of living of the entire Nation. They are, therefore, concerning themselves with the conservation and use of every economic resource. Thus there has arisen the apparent paradox that the more comprehensive and vast the over-all plan the more intense is the concern for little things, for the conservation of little waters, for example, and the wise utilization of small water powers.

What contribution may we reasonably expect the planned utilization of small water powers to make not only toward the cost of the major undertakings but also toward the diffusion of individual comfort and well-being and the stimulation of individual enterprise within their larger social and technological framework?

We no sooner ask the question than we are compelled to acknowledge the fact that the extent of potential small water powers in the United States has never been accurately determined. As indicating the chronology of the cycle outlined above, it is noteworthy that since 1921 the United States Geological Survey has omitted from its utilized power listings, as practically negligible, all separate installations which deliver less than 10,000 kilowatt-hours per minimum month, nearly equivalent to 100 horsepower of installed capacity under usual practice; and that our best sources of primary information relative both to the number and distribution of small water powers are the Thirteenth, Twelfth, and Tenth Censuses of the United States, those of 1910, 1900, and 1880, even though they

[1] Written for the Third World Power Conference, Washington, D. C., 1936.
[2] Chief, Soil Conservation Service.

fail to distinguish between small-power sites and small installations. The early use of water power at practically all prominent falls thus far utilized in this country inevitably, owing to the still primitive state of technological development, was through small installations. Even on the Niagara the average horsepower per mill as shown in table I based on the Tenth Census was 151, less than the reported horsepower per site on the New York State canals. And yet these tables do serve to convey an approximately accurate idea both of the number of small water powers and of their remarkably wide distribution throughout the 48 States and the District fo Columbia. An analysis of these statistics would seem to justify the inference that excluding those which might properly be classified as inaccessible or requiring too difficult construction, or lacking valley lands, dependable all-year water supply, and other facilities for establishing and maintaining homes and minor industries in the vicinity, the number of available sites deserving consideration in any comprehensive plan for the rational use of small water powers exceeds 50,000. This estimate is particularly supported by table II, which shows that the number of water wheels used in manufacture alone in 1879 was 55,404, and this at a time when extensive frontiers were but sparsely settled, and when no entire river system even approached complete development. Whether we should agree to define a small water power as of a dimension of 1,000 horsepower or less, or of 100 horsepower or less, it is obvious that our small powers in the aggregate represent a potential running into the millions of horsepower.

TABLE I.—*Selected data on water power from the Tenth Census of the United States, 1880: Water Power, pt. I, p. xxxix, et seq., also pt. II*

River	Drainage area (square miles)	Number of power sites	Number of mills	Horsepower used	Average horsepower		Maximum power site	
					Per site	Per mill	Capacity in horsepower	Number of mills
Coast streams of Maine	.....	450	1,491	86,139	192	58	7,800	6
Coast streams of New Hampshire	.....	64	168	11,235	176	67	3,475	2
Merrimack	4,916	24	46	39,937	1,662	867	11,314	4
Tributaries of the Merrimack	.....	397	878	48,904	123	56	4,100	1
Coast streams south of the Merrimack	.....	251	794	50,451	201	64	6,415	21
Connecticut	10,924	761	2,298	118,026	156	51	6,315	17
Hudson, N. Y	13,366	578	1,646	82,910	140	49	3,048	19
Niagara	.....	.....	27	4,083	.....	151	.....	.....
Huron, Mich	930	12	20	1,963	163	98	400	1
Black, N. Y	1,857	58	212	13,029	224	64	3,557	8
Oswego, N. Y	5,013	238	748	31,488	132	41	1,930	15
Genesee, N. Y	2,496	111	349	13,898	125	40	1,520	17
New York State canals, exclusive of feeders	.....	14	40	2,391	171	60	1,421	22
Pennsylvania State canals	.....	.....	.....	2,950	.....	.....	.....	.....
Ohio State canals	.....	71	150	6,618	93	44	800	5
Passaic, N. J	962	76	153	7,365	97	47	660	3
Delaware, including Schuylkill	12,012	427	2,110	55,855	131	26	2,069	89
Susquehanna	26,233	566	2,943	70,283	124	24	3,666	168
Potomac	14,500	156	1,007	18,790	121	18	1,710	84
James	9,700	145	469	13,323	92	29	700	1
Savannah	6,850	86	394	11,776	137	30	3,650	15
Allegheny	11,107	197	715	19,204	98	27	848	29
Alabama	23,700	124	630	10,169	82	16	900	7
Appalachicola	19,580	147	604	13,009	89	22	2,000	3
Monongahela	7,625	76	289	5,845	77	20	350	1
Muskinghum, Ohio	7,740	63	226	5,742	91	25	673	13
Kansas	59,730	89	146	6,561	74	45	255	4
Missouri River Basin, total	527,000	301	607	23,537	78	39	1,284	26
Arkansas	108,143	147	281	7,096	48	25	352	6
Red River	92,700	23	39	778	33	20	102	3

In the report of the Water Planning Committee already referred to, the authors wisely warn all concerned that to recommend for any river basin an inclusive water plan without exhaustive study of adequate data bearing on all phases of the many problems involved would be most illogical, would invite and deserve severe criticism, would involve economic waste, and might preclude the formulation of a well-balanced plan later. In the case of small water powers as in that of rivers to which they are tributary, fundamental data, the consideration of which is a prerequisite to effective planning and wise utilization, still are lacking in greater or less degree on both the surface and underground waters of most drainage areas throughout the country. In spite of the important position which small waters and more especially small water-power installation held in our earlier history, we must recognize that from the point of view of the emerging conception of over-all planning, multiple use, and integrated conservation and utilization of all natural resources, we are at a pioneering stage with respect to our knowledge of small water powers and the place which they should rightfully occupy in our master plans.

TABLE II.—*Water power utilized in manufactures in the United States* [1]

Year	Horsepower	Number of water wheels	Average horsepower per wheel	Total developed water power		
				Number of plants	Number of water wheels	Total horsepower
1869	1,130,431	51,018	22	.....	.....	1,130,000
1879	1,225,379	55,404	22	.....	.....	1,210,000
1889	1,225,045	.....	.....	.....	.....	1,300,000
1899	1,454,112	23,099	63	.....	.....	.....
1902	.....	.....	.....	.....	.....	2,050,000
1904	1,647,880	20,992	79	.....	.....	.....
1907	.....	.....	.....	.....	.....	3,250,000
1909	1,822,888	21,282	86	31,337	52,827	3,870,000
1914	1,826,443	18,065	101	.....	.....	5,790,000
1919	1,765,263	13,980	126	.....	.....	7,590,000
	Omitting all plants less than 100-horsepower capacity after 1921					
1923	1,803,000	9,293	194	.....	.....	9,090,000
1925	1,800,000	8,393	214	3,355	.....	11,180,000
1927	1,598,000	7,594	210	3,390	.....	11,720,000
1929	1,539,000	6,523	239	.....	.....	13,571,530
1930	.....	.....	.....	.....	.....	13,807,778
1931	.....	.....	.....	.....	.....	14,884,667
1932	.....	.....	.....	.....	.....	15,562,805
1933	.....	.....	.....	.....	.....	15,817,941
1934	.....	.....	.....	.....	.....	15,913,451
1935	.....	.....	.....	3,117	.....	16,075,307
1936	.....	.....	.....	3,067	.....	16,079,407

[1] (*a*) Tenth Census, 1880, Water Power, pt. I, p. xii; (*b*) Abstract of the Census of Manufactures, 1919, p. 460; (*c*) U. S. Census, 1929, Mfg., pt. I, p. 112; (*d*) The Economics of Water Power Development, 1928, Walter Henry Voskuil; (*e*) U. S. Geological Survey Water Supply Papers No. 579, p. 206 (1928); and No. 234, p. 29 (1909).

In examining available statistical sources, we are struck by their exclusive preoccupation with water as power, just as in the case of municipal engineers we are struck by their exclusive preoccupation with water supply, and in the cases of great flood-control works with the speeding up of run-off to the exclusion of power development and often with little consideration of soil conservation and use. Nevertheless, the data supplied by the Tenth, Twelfth, and Thirteenth Census reports have great value both in themselves and as guides to future research. Table III provides a comparison of power utilized in manufactures as reported by the census in 1870 and 1880, with geographical distribution by States. It is there shown that the growth of water power and steam power in the manufacturing field during the previous decade had been about 8 percent and 80 percent, respectively. Table I provides further details through selected data on water power relating to representative river and canal systems, and indicates that nearly all would be classed as small water powers if 1,000 horsepower is accepted as the basis of classification and due account is taken of the distinction between small water powers and small water-power installations.

Table IV shows the trend of water-power utilization in manufactures from 1869 to 1909, with regional distribution. It appears from these data that a steady growth continued throughout the 40-year period of record, with a total increase of 61 percent. Table

TABLE III.—*Reproduction from Tenth Census of the United States, Water Power, pt. I, 1, pp. xii-xiii; Power Utilized in Manufactures by Prof. George F. Swain*

	Water power			Steam power			1870		1880	
	Total in 1870	Total in 1880	Increase	Total in 1870	Total in 1880	Increase	Water power	Steam power	Water power	Steam power
Total in the United States	*Horsepower* 1, 130, 431	*Horsepower* 1, 225, 379	*Percent* 8. 40	*Horsepower* 1, 215, 711	*Horsepower* 2, 185, 458	*Percent* 79. 77	*Percent* 48. 18	*Percent* 51. 82	*Percent* 35. 93	*Percent* 64. 07
Alabama	11, 011	11, 797	7. 14	7, 740	15, 779	103. 85	58. 72	41. 28	42. 78	57. 22
Arizona	10	160	1, 500. 00	80 (35)	370	957. 14	11. 11	88. 89	30. 19	69. 81
Arkansas	1, 545	2, 024	31. 00	6, 101	13, 709	124. 70	20. 21	79. 79	12. 86	87. 14
California	6, 877 (4, 381)	4, 850	(1)	18, 493 (17, 072)	28, 071	64. 43	27. 11	72. 89	14. 73	85. 27
Colorado	792 (742)	1, 849	149. 19	1, 433 (761)	3, 953	419. 45	35. 60	64. 40	31. 87	68. 13
Connecticut	54, 395	61, 205	12. 52	25, 979	57, 027	119. 51	67. 68	32. 32	51. 77	48. 23
Dakota	76	803	956. 58	248	1, 421	472. 98	23. 46	76. 54	36. 11	63. 89
Delaware	4, 220	4, 785	13. 39	4, 313	10, 643	146. 77	49. 46	50. 54	31. 02	68. 98
District of Columbia	1, 100	880	(1)	789	2, 263	186. 82	58. 23	41. 77	28. 00	72. 00
Florida	538	939	77. 84	3, 172	6, 208	95. 71	14. 27	85. 73	13. 14	86. 86
Georgia	27, 417 (27, 356)	30, 067	9. 91	10, 826 (10, 811)	21, 102	95. 19	71. 69	28. 31	58. 76	41. 24
Idaho	295 (92)	1, 136	1, 134. 78	311 (191)	546	185. 86	48. 68	51. 32	67. 54	32. 46
Illinois	12, 953	17, 445	34. 68	73, 091	126, 843	73. 54	15. 05	84. 95	12. 09	87. 91
Indiana	23, 518	21, 810	(1)	76, 851	109, 960	43. 08	23. 43	76. 57	16. 55	83. 45
Iowa	14, 249	20, 363	42. 91	25, 298	33, 858	33. 84	36. 03	63. 97	37. 56	62. 44
Kansas	1, 789	7, 611	325. 43	6, 360	13, 468	111. 76	21. 95	78. 05	36. 11	63. 89
Kentucky	7, 640	9, 012	17. 96	31, 928	45, 917	43. 81	19. 31	80. 69	16. 41	83. 59
Louisiana	142	90	(1)	24, 924 (6, 628)	11, 256	69. 82	. 57	99. 43	. 79	99. 21
Maine	70, 108	79, 717	13. 76	9, 465	20, 759	119. 32	88. 11	11. 89	79. 34	20. 66
Maryland	18, 461	18, 043	(1)	13, 961	33, 216	137. 92	56. 94	43. 06	35. 20	64. 80
Massachusetts	105, 854	138, 362	30. 71	78, 502 (78, 450)	171, 397	118. 48	57. 42	42. 58	44. 67	55. 33
Michigan	34, 895	34, 395	(1)	70, 956	130, 352	83. 71	32. 97	67. 03	20. 88	79. 12
Minnesota	13, 054	28, 689	119. 77	7, 085	25, 191	255. 55	64. 82	35. 18	53. 25	46. 75
Mississippi	2, 453	3, 449	40. 60	10, 019	15, 001	49. 73	19. 67	80. 33	18. 69	81. 31
Missouri	6, 644	8, 162	22. 85	48, 418	72, 587	49. 92	12. 07	87. 93	10. 11	89. 89
Montana	795 (611)	954	56. 14	822 (226)	544	140. 71	49. 17	50. 83	63. 68	36. 32
Nebraska	1, 446	5, 495	280. 01	1, 865	2, 999	60. 80	43. 67	56. 33	64. 69	35. 31
Nevada	2, 538 (370)	108	(1)	6, 007 (636)	608	(1)	29. 70	70. 30	15. 08	84. 92
New Hampshire	68, 291	69, 155	1. 27	8, 787	18, 595	111. 62	88. 60	11. 40	78. 81	21. 19
New Jersey	25, 832	27, 066	4. 78	32, 307	72, 792	125. 31	44. 43	55. 57	27. 10	72. 90
New Mexico	659 (623)	932	49. 60	252 (103)	427	314. 56	72. 34	27. 66	68. 58	31. 42
New York	208, 256 (208, 106)	219, 348	5. 40	126, 107	234, 795	86. 19	62. 28	37. 72	48. 30	51. 70
North Carolina	26, 211 (26, 200)	30, 063	14. 74	6, 941 (6, 816)	15, 025	120. 44	79. 06	20. 94	66. 68	33. 32
Ohio	44, 746	38, 641	(1)	129, 577	222, 502	71. 71	25. 67	74. 33	14. 80	85. 20
Oregon	5, 806 (5, 766)	9, 255	60. 51	2, 471 (2, 451)	4, 334	76. 83	70. 15	29. 85	68. 11	31. 89
Pennsylvania	141, 982	110, 276	(1)	221, 936	402, 132	81. 19	39. 01	60. 99	21. 52	78. 48
Rhode Island	18, 481	22, 240	20. 34	23, 546	41, 335	75. 55	43. 97	56. 03	34. 98	65. 02
South Carolina	10, 395 (10, 386)	13, 873	33. 58	4, 537 (4, 487)	11, 995	16. 73	69. 62	30. 38	53. 63	46. 37
Tennessee	19, 514	18, 564	(1)	18, 467	33, 388	80. 80	51. 38	48. 62	35. 73	64. 27
Texas	1, 830	2, 508	37. 05	11, 214	28, 026	149. 92	14. 03	85. 97	8. 21	91. 79
Utah	2, 169	3, 535	62. 98	331 (319)	1, 154	261. 76	86. 76	13. 24	75. 39	24. 61
Vermont	44, 897	52, 226	16. 32	6, 425	11, 088	72. 58	87. 48	12. 52	82. 49	17. 51
Virginia	41, 202	37, 464	(1)	8, 410	19, 710	134. 36	83. 05	16. 95	65. 53	34. 47
Washington	1, 412	1, 185	(1)	1, 411	3, 210	127. 49	50. 02	49. 98	26. 96	73. 04
West Virginia	10, 195	9, 454	(1)	17, 136	28, 456	66. 06	37. 30	62. 70	24. 94	75. 06
Wisconsin	33, 714	45, 356	34. 53	30, 509	60, 729	99. 05	52. 50	47. 50	42. 75	57. 25
Wyoming	34 (0)	38	.....	310 (245)	717	192. 65	9. 88	90. 12	5. 03	94. 97

[1] Decrease.

NOTE.—In cases where 2 figures are given for the steam or water power of a State in 1870, those not enclosed in parentheses are the ones returned. Those in parentheses are the figures used in computing the percentages of increase and have been derived from the former by subtracting power used for purposes which in 1880 were not classified under manufactures. The table thus refers to power used in manufactures as classified in 1880.

II shows the trend in water-power utilization in manufactures from 1869 to 1929, together with the number of water wheels and average horsepower per wheel for each census there recorded, the later ones being at intervals of less than 10 years. These data disclose a fairly gradual rise up until 1914, thence a slight decline in total horsepower, while the number of water wheels decreased from more than 50,000 to 6,523 and the average horsepower per wheel progressively increased from 22 to 239. To provide a comparison, fragmentary data are added in the last three columns to show the growth of total developed water power during recent years in relation to use in manufactures.

Table V shows the distribution of water power used for flour- and grist-mill products in relation to the total power required for this industry—451,378 horsepower out of a total of 1,016,859, or 44 percent being supplied from water wheels with an average capacity of 21.7 horsepower in 1900. Reference to the second column of table II shows that for 1899 the total water power utilized in manufactures was more than three times that devoted to flour- and

TABLE IV.—*Water power used in manufactures from water wheels and motors, owned power only, from Thirteenth U. S. Census, 1910; pt. VIII, p. 348 (expressed in horsepower)*

Region	1869	1879	1889	1899	1904	1909
New England	362,026	422,905	497,031	619,209	659,071	757,332
Middle Atlantic	376,070	356,690	331,964	410,173	514,951	470,488
East North Central	149,826	157,647	155,245	171,077	194,871	208,441
West North Central	37,258	71,123	60,005	51,999	63,659	86,330
South Atlantic	139,729	145,568	145,397	124,830	137,018	183,158
East South Central	40,618	42,822	34,850	25,107	24,193	29,315
West South Central	3,517	4,622	4,552	2,760	3,236	3,108
Rocky Mountain	7,292	8,712	6,779	18,161	18,319	21,543
Pacific	14,095	15,290	19,222	30,796	32,562	63,173
United States	1,130,431	1,225,379	1,255,045	1,454,112	1,647,880	1,822,888

grist-mill products alone and represented fully three-fourths of the total developed water power; while in 1909, manufactures utilized less than half and in 1929 about one-ninth of the total, thereby reflecting the growth of electrical power and transmission systems as the principal factor in recent water-power development.

The character and extent of recent utilization of small water powers in the United States encompass the entire range of activities to which such energy is applied in either large or small quantities. In this connection it should be noted that the apparent reduction in the number of utilized water powers as shown in table II is partly attributable to the omission of all plants with less than 100-horsepower capacity after 1921—an unfortunate omission for which appropriate allowance must be made.

As has already been suggested, that omission is symptomatic of the difficulty which even highly trained men deeply concerned with the general ideals of conservation have found in escaping single-use preoccupations and in developing a comprehensive view of all the factors which must be interrelated if the highest economic and social interests of the Nation are to be effectively served. Among innumerable possible examples of that difficulty, two are here cited as illustrating strikingly contrasted stages in the evolution of our attitude toward stream regulation and use.

In the Muskingum Valley, Ohio, the best available census statistics and estimates account for 253 water powers utilized for grist and saw mills in 1880, 90 in 1904, and 14 today. It is a notable fact that the flood-control reservoirs now under way in the Muskingum conservancy district include no provision for power development, even though considerable head and storage capacity are available. As a result of the abandonment or absorption of small water powers by these reservoirs in the Muskingum Valley, some of the feed grinding for farm use is now done by portable engine-driven mills mounted on trucks. Where conservancy districts are organized for flood control solely, as in both the Miami and Muskingum districts in Ohio, the paramount consideration is protection of lives and property, and whatever concession is made toward water conservation after the flood crest has passed, is in the nature of an uneconomic compromise. It would require legislative amendment of their basic charters to permit these conservancy districts to develop their potential water powers; and any other agency seeking to sponsor power enterprises would find it impossible to realize full values from their investment, until joint agreements are worked out to coordinate such needlessly conflicting interests as power development and flood control. Actually, official estimates show that the best of the Muskingum sites could produce power well below the prevailing market price without interference with their function in flood control. That the authorities in this district are recovering from the earlier terrified preoccupation with flood control is indicated by an expression in an Ohio water conservancy board report which recommends repeal of a section of the General Code of the State law: "This law (forbidding the obstruction of water courses) has been so ruthless in its operation that dams have been blown out and streams have been straightened and dredged to get rid of the water as fast as possible."

In contrast with the picture in the Muskingum conservancy district is that of the condition of reservoirs in the southern half of the country where the preoccupation has been with storage without due consideration of land conservation and soil erosion. The importance of sedimentation as a present-day factor in reservoir maintenance in the various type regions of the country has been made a special subject of systematic investigation by the Research Section of Sedimentation and Hydraulic Studies of the Soil Conservation Service during the greater part of the past 2 years. To date, detailed capacity surveys have been made of some 30 reservoirs in the southern half of the United States to determine the actual volumes of silt that have accumulated in known periods of time. Also, reconnaissance examinations have been made of other reservoirs throughout the same region. Although these studies have dealt, for the most part, with reservoirs somewhat larger than small plants usually require, the results, with respect to rates of silt production from watershed areas under characteristic present-day erosion, are broadly applicable to the small reservoirs problem. This is particularly true of investigations made in the southeastern section of the country, where significant contrasts were found in rates of reservoir silting in the largely deforested and cultivated Piedmont agricultural region on the one hand, and in the adjacent forest-protected watersheds of the Appalachian Mountain province on the other.

Completely Filled Reservoirs

Practically all small reservoirs in the Piedmont and many others of major size that are more than a few decades old were found to be completely filled, except for a normal alluvial stream channel through the region of the original pond (fig. 1).

Typical of the smaller reservoirs are those of Deep River, downstream from the municipal reservoir of High Point, N. C.; Gil Reath's Mill on a tributary of Tiger River, South Fork near Greer, S. C.; Jenkins Mill on Glade Creek northeast of Gainesville, Ga.; and Barrett Mill dam on East Sandy Creek, Athens, Ga., shown in figure 2. Detailed description of the individual sites would be tedious repetition, for the most part, of complex histories of small dams having been constructed, filled, raised, and filled again. At the present time most of these small dams are practically without useful storage, and consequently, reduced in power capacity during low-water season to the ordinary discharge from small drainage basins.

In all the Piedmont there are literally scores of such smaller reservoirs, with dams 10 to 30 feet (3.1 to 9.2 meters) high, equipped to generate various amounts of power running generally from 15 or 20 upwards to 75 or 80 horsepower. Altogether, these smaller plants generate a really important aggregate power. Their intimate distribution and service among the rural communities of the Southern States for grist-mill and other local uses, makes their gradual deterioration particularly distressing to a large proportion of the population.

Some of the larger reservoirs filled to the point of practically complete elimination of storage as a factor of power production, are listed in table VI. An appreciation of the magnitude and rapidity of loss of storage capacity assets of these power plants can be conveyed better, perhaps by table VI than by detailed description of each individual case. The height of dam, where given, relates closely in most cases to original storage depth and capacity. The life in years given in the table is the approximate time required for complete filling, although in several instances the reservoir had

been nearly filled in shorter time, and stream-borne materials, including sand, had been occasionally passing over the dams for several years.

All of those dams are first-class concrete or masonry structures, and represent large initial investments. More than half are 30 to 50 feet in height and originally ponded water for distances of 4 to 7 miles. The fate of these dams indicates clearly the serious inroads already made upon developed power resources of the southern industrial region by accumulation of erosional waste, and the magnitude of the continuing menace to other power developments that have been or may be made in the erodible Piedmont region.

Appalachian Mountain Region

In contrast with the silt-filled reservoirs of the Piedmont, there are listed in table VII some of the reservoirs of the Appalachian Mountain region which have survived with negligible loss of storage capacity, in spite of steeper slopes. The soils of both regions are derived principally from granite and gneiss, of closely similar depth of decay and erodibility. The differences in land use must account for the different rates of sedimentation; the virgin forests or naturally reforested lands with only occasional agricultural plots of the mountain slopes proving to be more stable than the gentler slopes of cultivated Piedmont lands with the protective cover largely removed.

TABLE V.—*Production of flour and grist-mill products—Distribution of water power in the United States, 1900, from Twelfth Census Bulletin 199, pp. 20 to 31*

State	Number of establishments	Power			
		Number reporting	Total horsepower	Number of water wheels	Horsepower
Alabama	781	780	14,436	698	9,279
Arizona	11	11	604	6	292
Arkansas	410	411	10,091	132	2,448
California	124	123	11,058	36	1,412
Colorado	60	60	4,819	19	1,020
Connecticut	208	208	6,930	200	4,597
Delaware	83	83	3,803	106	2,484
District of Columbia	9	9	636	2	280
Florida	95	95	1,507	57	762
Georgia	1,123	1,114	25,037	1,244	18,410
Idaho	34	34	1,833	22	816
Illinois	871	866	46,467	134	3,853
Indiana	897	896	51,757	369	9,735
Indian Territory	61	61	2,278	8	202
Iowa	702	693	33,695	490	11,534
Kansas	333	322	31,386	194	8,207
Kentucky	1,145	1,144	31,086	508	8,103
Louisiana	69	57	1,102	2	25
Maine	227	225	8,619	251	6,492
Maryland	407	411	14,182	439	8,035
Massachusetts	231	227	9,536	229	6,464
Michigan	765	765	43,960	621	19,780
Minnesota	512	511	69,560	265	23,209
Mississippi	225	224	3,950	104	1,178
Missouri	1,145	1,135	47,947	317	6,291
Montana	20	18	1,451	22	931
Nebraska	305	304	16,649	208	7,875
Nevada	11	11	463	11	373
New Hampshire	149	149	7,249	220	5,922
New Jersey	354	353	13,975	403	9,712
New Mexico	35	35	1,086	24	519
New York	1,513	1,507	90,347	2,131	58,384
North Carolina	1,773	1,770	37,504	2,058	28,658
North Dakota	97	97	5,930	16	568
Ohio	1,150	1,150	65,489	615	15,640
Oklahoma	55	52	3,377	1	20
Oregon	153	152	8,390	132	5,540
Pennsylvania	2,719	2,709	96,531	3,017	53,812
Rhode Island	47	41	1,993	32	921
South Carolina	556	553	9,705	424	5,842
South Dakota	120	120	6,546	31	1,163
Tennessee	1,618	1,618	37,672	1,301	19,255
Texas	289	283	13,640	48	1,626
Utah	80	80	3,688	82	2,798
Vermont	211	213	13,111	408	11,990
Virginia	1,726	1,720	32,916	1,833	31,077
Washington	85	85	5,816	44	2,387
West Virginia	737	734	16,865	451	6,253
Wisconsin	717	717	47,713	775	22,887
Wyoming	10	10	465	6	297
United States	25,258	24,147	1,016,839	20,766	451,378

Average horsepower per wheel, 21.7.

TABLE VI.—*Reservoirs of the Piedmont agricultural region—Examples of filled reservoirs in various sections of South Carolina and Georgia*

River	Reservoir	Height of dam (feet)	Age (years)
Broad	Gaston Shoals, S. C.	39	28
	Parr Shoals, S. C.		
Enoree	Van Patten Shoals, S. C.	14	26
	Riverdale Mill, S. C.		
Saluda	Saluda, S. C.	44	29
	Holloday, S. C.	37	29
Savannah	Portman Shoals, S. C.	42	36
	Near Anderson, S. C.		
	Gregg Shoals, S. C.	14	27
	Near Iva, S. C.		
Oconee	Tallassee, Ga.	30	32
	Mitchells Bridge, Ga.	15	36
Yellow	Barnett Shoals, Ga.	45	23
	Millstead Dam		
Chattahoochee	Dunlop, Ga.	36	30
	Morgan Falls, Ga.	30	30
	Langdale, Ga.	14.5	28
	Riverview, Ga.	9	29
Total		388.5	383
Average		29.8	29.4

Rates of Silting Indicated

Prior to the investigations by the Soil Conservation Service during the past 2 years, capacity surveys to determine rates of silting had been made of some 25 American reservoirs. Among these reservoirs only 10 are of basin type, with original capacities large enough to permit practically complete natural desilting of all inflowing water and so to afford a practical index to comparative average rates of sediment delivery from their watersheds during periods of record. Table VIII presents a summary of the data on these reservoirs, including computations of average rates of silt accumulation per square mile of watershed area.

It is to be noted that these records of earlier reservoir surveys relate almost exclusively to the relatively dry southwestern sections of the country where flood flows of streams are generally conspicuously charged with silt and where the seriousness of sedimentation as a limiting factor of reservoir life has long been widely recognized. The recent extension of reservoir studies into other type regions of the country indicates that the sedimentation factor is fully as important, if not more so, in humid regions wherever vegetative restraints have been removed or weakened sufficiently to introduce accelerated erosion. This is shown by table IX which summarizes the significant data of reservoir surveys by the Soil Conservation Service in the southwestern, south central, and southeastern sections of the country.

The foregoing data show that the present rates of sedimentation in reservoirs, both large and small, throughout broad regions of the country generally range from a quarter to one or more acre-feet of silt per square mile of tributary watershed. Although these tabulations, when segregated for arid and humid regions, respectively show average annual silting rates of 1.25 or 0.65 acre-foot per square mile of drainage area, it is apparent that the data are not strictly comparable, but only approximately so.

The foregoing and related data from the recently completed country-wide reconnaissance survey of erosion conditions, carried out by the Soil Conservation Service, shows that accelerated erosion, in one form or another, is almost universally prevalent in all but the more sparsely populated regions of sloping lands, and that the sedimentation factor has increased accordingly. In considering the question of present-day possibilities of small water powers,

TABLE VII.—*Reservoirs of the southern Appalachian Mountain region—Examples of reservoirs in various sections of North Carolina and Georgia which have survived with negligible loss of storage*

River	Reservoir	Height of dam (feet)	Age (years)
Little	Little River near Brevard, N. C.	.....	25
Green	Green River near Tuxedo, N. C.	.....	18
Upper Catawba	Bridgewater or Lake James near Morgantown, N. C.	135	17
Upper Tugalo	Burtin	114	9
	Raburn	.....	.....
	Nacoochee	63	10
	Tallulah near Tallulah Falls, Ga	.....	22

we therefore cannot rely solely upon the early day history of such power in this country. We must also take into account the actual discharges and silt loads that our streams now carry. Outside of limited regions that are as yet but little affected by human influences, and by the same token are generally unfavorable to power developments because of lack of suitable populations to be served, the accentuation of the sedimentation factor by unchecked erosion appears to militate selectively against the smaller water-power enterprise.

Fortunately, the measures of erosion control that are coming more and more into justified use for land conservation alone are necessarily effective also in reducing direct surface run-off and silt production, while increasing infiltration and ground-water storage. In many cases and perhaps quite generally in agricultural regions, the small water-power possibilities are thus directly integrated with the problems of salvage and conservation of land and water resources. Under these circumstances it would seem eminently in order to consider these two problems together wherever they can be served in common by research and by practical erosion-control work on the watersheds involved.

Whether we consider the story of flood control as illustrated in the Muskingum conservancy district, or the silting of reservoirs, it becomes increasingly clear that we must develop a new approach to problems of the conservation and utilization of little waters and small water powers, and that that approach must have reference to the planned conservation, development, and use of all the resources of entire drainage areas. We must see flood control in relation to power, power and water storage in relation to soil conservation, soil conservation in relation to forests, grassy ground cover, and the conservation of the natural headwater reservoirs upon which the flow both of surface and subsurface waters so intimately depends.

Now, it happens that there is no drainage area in America in which the interdependence of all these elements has been so fully considered as that under the jurisdiction and influence of the Tennessee Valley Authority, and it is significant that there are few if any comparable areas in which there are so many small water powers in use and in process of development, although the facts are only in part attributable to the comparatively recent activities of the Authority. It must be remembered, however, that the spirit and direction of those activities have had their precursors in the work of the land-grant colleges and the univeraities of the Tennessee Valley States, many members of whose staffs are today directly and cooperatively engaged in the work of the T. V. A.

In contrast to decline in the utilization of small water powers in the Muskingum area, the Tennessee Valley has about 1,700 small water-power plants of 100-horsepower or less capacity, devoted to a wide variety of farm, household, and industrial uses. Of these plants, 912 are in Tennessee, 404 in North Carolina, 162 in Virginia, 120 in Georgia, and 81 in Alabama, according to information furnished by Prof. Sherman M. Woodward, chief water control planning engineer of the Tennessee Valley Authority.

The main uses to which the small water powers of Tennessee Valley are applied are the following:

(A) One- to five-family mill, used for grinding meal but not for producing flour.

(B) Small community mill, used for grist and feed grinding, occasionally for sawmill operation, and for generating electricity for household use at night.

(C) One-family electric plants, mostly using either belt-driven or geared direct-current generators driven by the water wheels.

(D) Small community electric plants, the outgrowth from what were originally one-family plants. To take care of the peak demands where capacity or stream flow is otherwise insufficient, it is common practice to install a set of storage batteries that can be charged at a constant rate and discharged at the will of the owners.

(E) Mineral mills, driven by either water wheels or by turbines, utilized for pulverizing either mica or clay, and often utilizing part of the power for electric lighting.

In table III it appears that only 18,564 horsepower were utilized in the entire State of Tennessee for manufactures in 1880. If the average capacity per wheel was 22 horsepower, as reported for that

TABLE VIII.—*Silting records of reservoirs of higher capacity inflow ratio*

Reservoir	Stream	Location	Original storage capacity per square mile of drainage area (acre-feet)	Annual silt accumulation per square mile of drainage area (acre-feet)	Percentage of original capacity per year depleted by silting (percent)	Period
White Rock	White Rock Creek	Dallas, Tex	159.28	1.19	0.69	1923–28
				1.36	.85	1910–35
Elephant Butte [1]	Salt River	Hot Springs, N. Mex	100.29	.83	.83	1915–25
				.52	.52	1925–35
Roosevelt	....do	Roosevelt, Ariz	284.25	1.16	.41	1910–25
Lake Michie	Flat River	Durham, N. C	74.53	.17	.16	1926–30
				.26	.36	1926–35
Lake Worth	West Fork Trinity River	Fort Worth, Tex	25.20	.57	2.24	1915–28
Lake McMillan	Pecos River	Carlsbad, N. Mex	4.09	.08	2.14	1894–15
				.0159	.38	1915–25
				.0095	.23	1925–32
Zuni	Zuni River	Black Rock, N. Mex	31.62	1.10	3.48	1907–17
				1.20	3.83	1917–27
Sweetwater	Sweetwater River	Sunnyside, Calif	99.60	.90	.90	1888–95
			121.17	.74	.61	1895–16
			200.92	.48		1916–27
Lake Cabot	San Leandro River	Oakland, Calif	404.70	1.73	.42	1875–23
Gibraltar	Santa Inez River	Santa Barbara, Calif	73.00	.80	.55	1920–25
				1.25	.91	1925–31
				3.00	2.44	1931–34

[1] Period of subnormal rainfall and increased silting in the valley above the reservoir.

TABLE IX.—*Reservoirs surveyed by Soil Conservation Service 1934 to 1936*

Name of reservoir	Location	Storage per square mile of drainage area (acre-feet)	Annual silt accumulation per square mile of drainage area (acre-feet)	Percent of original capacity per year depleted by silting (per-cent)	Period
Lake Michie	Durham, N. C.	74.53	0.26	0.36	April 1926 to January 1935.
University Lake	Chapel Hill, N. C.	70.90	.80	1.14	June 1932 to April 1935.
Greensboro Reservoir	Greensboro, N. C.	39.80	.31	.78	February 1923 to August 1934.
High Point Reservoir	High Point, N. C.	72.00	.60	.84	August 1927 to August 1934.
Lake Concord	Concord, N. C.	316.07	2.05	.63	March 1925 to May 1935.
Spartanburg Reservoir	Spartanburg, S. C.	29.30	.62	2.10	May 1926 to July 1934.
Lloyd Shoals Reservoir (Ocmulgee River)	Jackson, Ga.	81.35	.41	.51	December 1910 to March 1935.
Rogers Reservoir	Rogers, Tex.	300.00	5.68	1.90	September 1922 to September 1934.
Lake Waco	Waco, Tex.	23.15	.57	2.48	April 1930 to March 1935.
White Rock Reservoir	Dallas, Tex.	159.28	1.36	.86	1910 to 1935.
Guthrie Reservoir	Guthrie, Okla.	228.91	2.35	1.03	October 1920 to May 1935.
Boomer Lake	Stillwater, Okla.	307.98	1.82	.59	March 1925 to June 1935.
Elephant Butte Reservoir (Rio Grande)	Hot Springs, N. Mex.	100.29	.68	.68	January 1915 to April 1935.
San Carlos Reservoir (Gila River)	Coolidge Dam, Ariz.	92.15	.43	.46	October 1928 to February 1935.

year in the entire United States in table II, this would represent only about 830 mills run by water power; or if the average capacity was as low as 10 horsepower per wheel, the number of plants was 1,856. It may be inferred, therefore, that the general decline in utilization of small water powers since 1880, as noted elsewhere herein, has not extended to the Tennessee Valley. In fact, along with recent extensive developments of large power projects, there is an awakened interest in the possibilities of small water powers. During the past few years the number of new plants and rehabilitations of old ones seems to have about kept pace with the plants abandoned.

It is significant that the development of large power plants and the widespread distribution of electric energy seems to stimulate the demand for utilization of available sites for small water powers and to enhance their value. Indeed, from the point of view of the rationally planned utilization of small water powers, either as units in an electric-utility distribution system or in projects for community or rural development, the higher significance of the facts in the Tennessee Valley is that they are there being envisaged in the relation to the controlled conservation and development of the total resources of an entire drainage area, and specifically in relation to the standard of living of the people not only in the valley, but throughout the Nation.

Crude and inadequate as our statistical information as to the extent and aggregate volume of small water powers is, the answer to the question as to the economic practicability and the social advantage of their planned utilization is not in doubt; but the measure of their ultimate value will depend upon the ability of engineers and economists and of supporting public opinion to grasp the interdependence of soil conservation, flood control, water supply, and power development. The problem of the effective utilization of small water powers, like the problem of the conservation of little waters, is not an isolated problem; it is inherent in the problem of total resource conservation and use, upon the wise solution of which the permanence of our American civilization depends.

Summary

The reawakening of interest in little waters and small water powers is a significant example of a profound transformation of the traditional American attitude toward conservation of natural resources. We are becoming land- and water-conscious in a new sense.

Small water powers played a major role in the colonial history of the industrial East, but their recognized importance was greatly diminished by the coming of coal, the concentration of population in manufacturing centers, and the shifting of interest from water power to water supply. The cycle which the steam engine effected through concentration in the East, the steam locomotive induced through dispersion of population over western plains.

The disastrous effects upon the conservation of little waters and the use of small water powers resulting from narrow preoccupation with single phases of stream regulation, whether water supply, flood control, or small water storage is illustrated by the threat of water famine in great metropolitan centers, the neglect of power development in such flood-control methods as those followed in the Muskingum conservancy district, and the sedimentation of important reservoirs especially throughout the southern region. These facts lend particular interest to the situation with respect to the survival and development of small water powers in the Tennessee River drainage area now under the control of the Tennessee Valley Authority.

Inadequate as our statistical information is, and urgent as is the need for comprehensive research, we are justified by available data in placing the number of small water power sites at more than 50,000 in estimating their aggregate potential in the millions of horsepower. But their effective utilization depends upon the ability of engineers, economists, and supporting public opinion to grasp the interdependence of water supply, flood control, soil conservation, and power development. The utilization of small water powers is inherent in the problems of total resource conservation and use.

WIND AND WATER EROSION

Twenty counties, lying in a compact area about the meeting place of the five State-boundary lines in the Southern Plains region, have been surveyed in considerable detail by the Soil Conservation Service. Approximately 25,000 square miles are involved in the area studies. It was found that the land affected to a serious degree by all types of erosion, wind, and water amounts to 53.4 percent of the whole area. Only about 15 percent of the erosion was the result of run-off. This land needs a heavy cover of strong grass, and trees where trees will grow.

AN INCH OF WATER

On lands adapted to crops, good farmers have proved that 18 inches of rainfall, the rough yearly average for the Plains, is sufficient moisture for a permanent agriculture, if properly utilized. If 1 inch of water runs off an acre of land, a tank wagon holding a ton would have to make 113 trips to bring the water back. Vegetation provides a protective mantle against wind and sun and makes it possible for the land to absorb a greater amount of rainfall when it comes.

DR. BENNETT APPOINTED

The President has appointed Dr. H. H. Bennett, Chief of the Service, as a member of a committee to confer with farm organization leaders and others regarding the development of a crop insurance program.

FARM WOODLAND RETURNS[1]

By E. V. Jotter[2]

The present consideration is a discussion of dollars-and-cents return to the individual landowner, rather than of the more intangible public values. It is true that today there is general appreciation of the efficacy of forest cover for maintenance of desirable soil and moisture conditions. The relation of 185,000,000 acres of farm woodland to surface and underground waters, and in turn to domestic water supplies, to irrigation, to transportation, and to power is conceded. The biological influences of forest wildlife such as the activities of soil microorganisms in their effect upon soil and moisture, and of woodland bird dwellers, especially their control of harmful insects, are recognized. The contributions of woodlands to recreation through the satisfaction of social and esthetic ideals, to pleasant farm surroundings, and to balanced land-use, are stressed in these days of lengthened leisure. They are all appreciated, but these are the public benefits. Except in a very general sense, they are not profits recognized by the individual when he considers his business. When the farmer asks, "What will I get from the farm woods?" he is none the less a patriotic citizen.

Cash from Wood Lots

To farmers in many parts of the United States the cash received from wood lots within the past few years represented a large portion of their entire cash income; often this income was what made possible a continued though inadequate existence on submarginal farm crop land. It was the extra cash that helped them "get by." As has long been the case in European countries, woodland returns in the United States are becoming of real economic significance. Almost $63,000,000, exceeded in cash income by only eight agricultural crops, came to farmers from their wood lots during the period of relatively low prices in 1934. When to this is added the value of woodland products used on the farms, the sizable figure of $116,000,000 is reached.

What are some of the records of individual farm returns? Here are a few examples:

A farmer in Muskingum County, Ohio, so LeRoy Frontz of the Soil Conservation Service reports, bought a farm including one building only, for which in 1918 he paid $1,500. On this farm, part hillside and part bottom land, past owners had starved out.

The present owner exercised good management in his use of the farm woods. He hired a portable sawmill and cut sufficient lumber to build a barn, a shed, a hog pen, and a chicken house. The remainder of his lumber was disposed of at a profit of $2,000, which more than paid his original investment in the farm.

Now he still has a woods with some merchantable timber. Other areas have young growth, which would have been true of the entire stand had he kept stock out of it.

They Burned Wood

In our own Service, John Fry, forester on the Coon Creek erosion-control project in Wisconsin, made a woodland-products survey on 118 farms within the area. He found the average farm woods produced in the winter of 1934-35, 11.3 cords of fuel wood worth $4 per cord, 649 board feet of lumber at $25 per thousand, 41 railway ties worth 35 cents each, and 259 posts valued at 10 cents each. The survey showed that the average farm included in the study produced in 1 year woodland products valued at $101.67, of which $87.32 was the value of products utilized on the farm. The fuel wood used on the average farm was equivalent in heating value to 9½ tons of anthracite coal. These woodland products, had they been purchased in the open market, would have cost the farmer $228.02 annually. Hence, these farmers saved $140.70 per year in actual cash by owning and utilizing productive woodland property.

The wages for services accruing to the farmer, where he uses his own labor or that of employees whose time might not otherwise be profitably employed, are important in this farm economic program. In view of this, it is curious that there are so few examples of profitably managed woods. Not only is there a general failure to

[1] This is the fourth article in a series.

[2] Senior forester, Woodland Section, Soil Conservation Service.

tend woods, as is done with other farm crops, but fire and stock continue in many areas further to destroy the trees, the brush, and the woodland soil.

The New Outlook

Today it is gratifying to note that along with the development of a program to control soil and moisture, to institute better land use, to provide more farm revenue, there is increased recognition of the farm woodland. Some States and neighborhoods have made marked advance in the development of the program. The efforts of Federal, State, and private foresters, of a few large wood growers and users, and of farmers, singly and in organizations, are beginning to bear fruit.

In this program of woodland development the project manager and his technical aides, especially the forester, have unusual opportunities and responsibilities. Woodlands are recognized as a part of the farm program of farm use and returns. Farmers need firewood and fence posts, flue wood for tobacco curing, tomato or grape stakes, repair parts for a wagon or sled, rustic furniture, an arbor. It is part of the job to show the farmer when it is better farm economy to get and fashion the material from his own wood lot than it is to buy it.

That the farm woodland is destined to become an increasingly important factor in the control of erosion and the rehabilitation of worn-out soils is a generally recognized fact. Not so universally established, however, are the superior competitive advantages which, as a producer, the farmer possesses in supplying community lumber needs. The farmer, through his own activities and the help he can get, especially because the work may be odd-time labor, is in a superior position with respect to labor cost as compared with the owner of extensive timber holdings. Fire control within the agricultural area is relatively simple and obtainable at low cost.

The farmer can quickly sell or refrain from selling, and all his operations possess the advantage of quick response to current market trends. The farmer need not cut when there is a low market; he does not have to operate the woods to carry on his business.

Two barns, a shed, a poultry house, 2,000 gallons of maple sirup, all the fuel wood used between 1910 and 1933, came from the 10-acre farm woods of Glenn Ingram. In addition, 23,500 board feet of lumber was sold and materials furnished for farm repairs. Present value of woods, $2,500.

In the farm woods there is a minimum of waste; where utilization of small lengths is possible, and top limbs or other unmerchantable saw timber can be sold or used as firewood. Such operations, because under direct supervision and personal interest of the owner, facilitate the betterment of the property, assuming that the farmer knows how to go about the work.

Certain parts of the United States have peculiar local advantages in supplying woodland products. Proximity to a pulp mill, opportunity to grow pulpwood at low costs, a good nearby market for furniture wood, for mining, timbers for summer cabins, for decorative material, for basket manufacture—the list could be multiplied.

Farm Land for Wood Crops

To the question as to just how much can be grown per acre per year there can be a general answer only. As well ask how many bushels of corn or wheat can be grown per acre, or how much forage can be produced. There are sites and sites; and, also, there are submarginal timber areas as well as submarginal annual crop areas. The forester can generally estimate returns expected; give him an opportunity and his figures as to future yields will check as closely as those of the other specialists.

The use of part of the farm for wood crops will be one of the features of a new agriculture. Foresters can help in bringing it about. Under the advice of competent and experienced technicians materially higher returns may be obtained.

THE INSPIRING STORY OF GOLDEN GATE PARK

(*Continued from page 73*)

Within the shelter furnished by these plants were gradually developed lawns and flower beds, nooks and walks, lakes and waterfalls, all embowered in masses of flowering shrubs and trees, the whole constituting a masterpiece of the landscape artist. The many thousands of plant species tried in the course of this horticultural experiment were of course not all equally successful, but the majority did survive and today serve to make Golden Gate Park a botanical garden in fact, if not in name.

Of recent years the work of plant introduction is being pursued more systematically, particular attention being given to plants native to regions having a climate similar to that of California. Several floral provinces having a like amount of rainfall, a rainless season of about the same duration, and a similar mini-

mum temperature in winter, have been especially fruitful in yielding novel plants for the park collection.

Australia, especially western Australia, has perhaps contributed more than the rest of the world combined, including many interesting and beautiful proteads, bottlebrushes, acacias, etc. New Zealand, if somewhat more humid, has yielded a nearly equal number of useful and showy plants, many of which are a legacy from the 1915 Exposition. South Africa's special contributions are the many kinds of heathers, some of which are sent by the carload to Eastern markets for cut flowers from the Bay region. Chile, too, has furnished numerous ornamental items. The so-called Mediterranean region has contributed much of value, as Cistus, Cytisus, lavender, etc., most of which have the merit of greater frost resistance than plants from the Southern Hemisphere.

In recent years a great many novel plants have been introduced from China and adjacent regions, among which the various species of rhododendrons must rank first. The various species and hybrids of rhododendrons easily constitute the horticultural highlight of the park season, and during April and May many plant lovers make pilgrimage, often from far away, to see the park's rhododendrons in flower. Numbering over 200 named varieties and nearly as many wild species, the park's collection of rhododendrons must be counted as one of the country's finest. An even more exotic impression is created by the park's fine groups of tree ferns. To see these giants of the moist tropics thrive like this in what originally was a sandy desert is a surprise indeed and an accomplishment of which one may well be proud.

In the near future an even more intensive development of this botanical side of the park is contemplated, with the fruition of plans for an arboretum, financed by a private bequest.

Space is lacking to tell of the many recreational features now sheltered here. The creation of Golden Gate Park is undoubtedly an outstanding example of successful soil conservation and reclamation.

SEEDING NATIVE GRASS IN CONTOUR FURROWS

By Wayne Austin [1]

With hundreds of miles of pasture terraces and contour furrows to be seeded on Colorado projects last spring, there was need for some type of hand-seeder capable of handling native grass-seed mixtures without clogging.

The common types of machine broadcasters clogged badly and failed to place the seed in the furrow. Broadcasting by hand was found to be very slow and unsatisfactory. The maximum possible by this method was 7 miles of furrow per day, and the seed was unevenly distributed. Invariably, more seed was used than had been estimated. Finally, we met the problem satisfactorily by adopting to our purpose a standard make of crank duster.

Among the changes necessary for converting the machine are the following:

1. Remove the wire agitator in top of hopper and eccentric drive rod.
2. Remove wheel agitator and break off two opposite wings. Extend the other wings laterally by soldering an extension near the tip.
3. Cut an oval hole 4½ inches long in the bottom of spout directly underneath the grill.
4. Solder a 10-inch tongue just in front of top of fan opening which has been cut at the bottom of the spout.
5. Cut off about 4 inches of the tube that extends in front of the machine and place it on the lower end of a new piece of tubing that has been made to fit the opening below the grill. The old opening is then soldered shut.
6. File the openings of the grill to a large size so that coarse seed can drop through. The regulator will still be effective to handle small seed. The size of the openings on the grill will depend upon the rate of seeding and the type of mixture.

With this machine, we are able to seed from 12 to 14 miles of contour furrow per day with ease, and at the same time get an even distribution of seed. By using the extension tube and spreader, it is possible to seed on windy days, an important factor in windy eastern Colorado. The machine is equipped with a fan which propels the seed out of the tube, forcing it into cracks and crevices in the soil where it will have a favorable chance to germinate.

The following species of plants are being seeded in various mixtures on these projects: *Melilotus alba, Bromus inermis, Agropyron smithii, Sporobolus airoides, Sporobolus cryptandrus, Bouteloua gracilis, Stipa robusta, Stipa spartea, Stipa comata, Atriplex canescens (wings removed), Elymus canadensis, Calamovilfa longifolia, Oryzopsis hymenoides, Andropogon furcatus, Andropogon scoparius, and Sorghastrum nutans.*

[1] Assistant agronomist, Soil Conservation Service.

STONE TERRACES OF KENTUCKY

(*Continued from page 65*)

vigorous growth of sumac and briars. On one of the unterraced, badly gullied slopes half of the area has been retrieved and completely stabilized by black locusts.

Except for the two benches cleared for cultivation by the present farm operator, the terraced hillsides are abandoned. But although we have improved upon the system of tillage which once prevailed there, we may learn much from the pioneering done here. With up-to-date methods, we may build soil-saving devices with less expenditure of effort, but we will do well to construct terraces that defy time and the elements as successfully as those built on this monastery farm nearly a century ago.

BOOK REVIEWS AND ABSTRACTS

By Phoebe O'Neall Faris

THE DESIGN OF EXPERIMENTS. By R. A. Fisher. Edinburg. London. 1935

This new book by the author of Statistical Methods for Research Workers and The Genetical Theory of Natural Selection is designed to illustrate the principles which are common to all experimentation, by means of examples chosen for the simplicity by which these principles are brought out; to exhibit the principal designs which have been found successful in the field of agricultural experimentation; and to illustrate their applicability to other fields of work. Chapter headings include the following: An Historical Experiment on Growth Rate; An Agricultural Experiment in Randomised Blocks; The Latin Square; The Factoral Design in Experimentation; Confounding; The Increase of Precision by Concomitant Measurements; Statistical Control; The Generalization of Null Hypotheses; Fiducial Probability; The Measurement of Amount of Information in General.

THEODOR BRINKMANN'S ECONOMICS OF THE FARM BUSINESS. Translation from the German. 1935.

Representative of modern German ideas concerning problems of agricultural economics, especially the problems of farm management.

Contains a general consideration of the types of farming; the levels of intensity in agricultural production and the orientation of its location; systems of farming or the orientation of the locations of the lines of production.

HANDBOOK OF NORTHWEST FLOWERING PLANTS. By Helen M. Gilkey. 1936.

The boundaries of the area covered in this handbook include roughly those of the rather natural floristic unit from the summit of the Cascades to the coast line of Washington and Oregon, as far south as the Umpqua Divide or about the southern limit of Lane County, Oreg. Analytical key, Glossary, Index.

SOIL SCIENCE, ITS PRINCIPLES AND PRACTICE. By W. W. Weir. Philadelphia. 1936.

Dr. Weir presents a new text on the study of soils and their classifications, soil fertility, and agricultural practices. Fairly extensive treatment is given the subjects of chemical nature and microbial populations of soils.

GAME MANAGEMENT. By Aldo Leopold. New York and London. 1936.

This book explains the possibilities of coordination between science and use in the field of conservation by game management. The subject matter is assembled by means of the productivity factors, i. e., the decimating factors (hunting, predators, starvation, diseases and parasites, accidents) on the one hand, and the welfare factors (food supply, water supply, coverts, special factors) on the other, the object being, apparently, to portray the mechanism which produces all species of game for all particular species, or the managing of particular lands. Special treatment is given the subject of game populations, with figures and charts on flight limits of bobwhite, grouse, partridge, pheasant, etc.; comparative mobility of game birds and animals; sex ratios; transplantation and domestication, as aids in determination of potential productivity. The game range is defined as a region habitable for a given species when it furnishes places suitable for it to feed, hide, rest, sleep, play, and breed, all within the reach of its coursing radius; and game management deals with offsetting deficiencies in any or all of these essentials and in keeping range types—farm game, forest and range game, wilderness game, migratory game—in balance.

The book contains sections on predator control, refuges, control of food and water, cover, control of disease, and accidents, and attempts to rationalize and classify the multitude of factors involved in game surveys and control management. A chapter with the title "Miscellaneous techniques" contains discussions on practical subjects such as artificial propagation, nesting studies, game maps and range tallies, game surveys. The author closes his book with a discussion of game administration and an outline of game as a profession, with some helpful information as to training and qualifications for game experts.

Appendix contains more than 400 references, with asterisked items recommended to the student of game as general reading; glossary of terms used in game management; breeding potential tables; index.

MAN'S INFLUENCE ON THE EARTH. By R. L. Sherlock. London.

This little book out of England tells a story of man's digging into and scratching over the surface of the earth: Interference with the flow of water, causing denudation; destruction of igneous rocks of deep-seated origin and making other rocks more to his liking; alterations of sea coasts so that his ships may anchor where he wills and he may build a city on so-called reclaimed land, the making of a desert where nature intended a forest or a wide plain with tall grass, and thereby modifying climate. Although the author limits fact and figure to Great Britain as a definite area, his message is none the less applicable to all other parts of the world where civilization with its iron and steel, its huge cities, its agricultural regions where the soil is worked forcefully and fiercely to the very bed rocks, and its precious gems, marches steadily onward through the centuries.

ELEMENTARY PLANE SURVEYING, TEXT AND MANUAL. By Raymond E. Davis. New York and London. 1936.

Treatise designed for students in architecture, forestry, and electrical and mechanical engineering. Contains map drafting; methods of plotting; calculation of areas of land; topographic mapping; the plane table; topographic surveying; route surveying; land surveying; determination of latitude and azimuth.

Field and office problems. Tables. Index.

U. S. GOVERNMENT PRINTING OFFICE: 1936